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SYSTRON DONNER

INSTRUCTION MANUAL

VIKING LABORATORIES INC.

MODEL 410

SWEEP/FUNCTION GENERATOR

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SYSTRON DONNER CORPORATION

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MODEL 410 SWEEP/FUNCTION GENERATOR

The Model 410 Sweep/Function Generator is a highly versatile and reliable laboratory instrument capable of generating sine, square, triangle, ramp, sine squared and pulse outputs over a frequency range of from 0.0002 Hz to 2 MHz. This instrument features dual channel outputs, each having independently controllable amplitude, offset, impedance and attenuation. The output voltage is 40 volts peak-to-peak maximum, open circuit, with a dynamic amplitude range of 80 dB (2 mV p–p to 20 V p–p into 50 ohms). Sine distortion is less than 0.25% through the audio range and less than 0.5% up to 200 kHz. In the sweep mode, the sweep generator sweeps from 1 to 100% of the main generator dial at rates of from 10 s to 100 S. The sweep and main generators can be gated or triggered by an external source or the instrument can be configured so that the sweep generator functions as a trigger or gate source for the main generator. An FM input is provided for externally controlling the frequency and an AM input provides for the amplitude modulation of the sine, square, triangle and ramp waveforms. A 1 volt peak-to-peak output is provided for synchronization and calibration.

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LIST OF SCHEMATICS

Drawing Number	Description
41000-226	Functional Block Diagram — Model 410 Sweep/Function Generator
41000-224	Block Diagram — Model 410 Sweep/Function Generator
40000-402	Schematic — Main Generator
40000-403	Schematic — Sweep Generator
40000-404	Schematic — Sine Generator
40000-406	Schematic — Output Amplifier Channel A and B
40000-405	Schematic — Amplitude Modulation
40000-401	Schematic — Power Supply
40000-407	Schematic — Front Panel
37000-928	Assembly — Printed Circuit Board

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SECTION I

SPECIFICATIONS

FUNCTION

Waveforms: sine, square, triangle, ramp, pulse and sine squared.

PERFORMANCE CHARACTERISTICS

Frequency Range: 0.0002 Hz to 2 MHz in 9 ranges.

Dial Accuracy: 2 Hz to 200 kHz ≤1% of setting, 0.2 Hz to 2 MHz ≤2% of setting, 0.002 Hz to 0.2 Hz ≤2% of full scale.

Frequency Vernier: approximately 1% of full scale (2 minor dial divisions).

Time Symmetry (all waveforms): >99.5%, 2 Hz to 200 kHz. >99%, 0.002 Hz to 2 Hz. >98%, 200 kHz to 2 MHz.

Frequency Stability: < ±0.05% for 1 hour. < ±0.5% for 1 month.

Sine Distortion: < 0.25%, 2 Hz to 20 kHz, < 0.5%, 0.002 Hz to 200 kHz. < 3%, 200 kHz to 2 MHz.

Sine Frequency Response: reference 1 kHz at maximum amplitude into 50 ohms. < ±1% to 200 kHz. < ±3% to 2 MHz.

Square Wave Rise/Fall Time: < 50 ns.

Square Wave Aberrations: < ±5%.

Trigger Input: >1 V peak-to-peak.

OUTPUT CHARACTERISTICS

Amplitude: >40 V peak-to-peak maximum, open circuit.

Amplitude Range: 80 dB (2 mV peak-to-peak to 20 V peak-to-peak into 50 ohms).

Stability (amplitude): < 0.1% for 1 hour.

Power: >2 W maximum into 50 ohms (square wave).

Impedance: >50 or 600 ohms, selectable by front panel switch.

DC Offset: ±20 V, open circuit. ±10 V terminated. (Combination of output amplitude and offset not to exceed ±20 V open circuit, or ±10 V terminated).

Sync Amplitude: 1 V peak-to-peak ±1%.

MODES OF OPERATION

Normal, Triggered, Gated, Sweep and Internal Trigger Gate.

MODULATION

Frequency: DC coupled. Approximately 25 mV input for 1 minor division dial deviation (4.5 V for 0.2 to 2 dial deviation). Range is >1000:1. Input impedance is 10 k ohms.

Amplitude: DC coupled. +5 V peak-to-peak input for 40 V peak-to-peak maximum at either output amplifier. Waveform to be modulated is selectable. Input impedance is 10 k ohms.

SWEEP GENERATOR

Duration: 10 μs to 100 s in 7 ranges.

Width: 0 to 100% of main generator frequency dial in 3 ranges.

Sweep Ratio: >1000:1.

Output: 5 V peak-to-peak, fixed amplitude. Output impedance is 50 ohms.

Modes of Operation: normal, triggered, internal trigger gated.

GENERAL INFORMATION

Power Required: approximately 50 W, 50–60 Hz at 105–125/210–250 V ac selectable by means of a multitap transformer and a range switch on the back panel.

Operating Temperature: 0 to 50° C. All specifications guaranteed over an ambient temperature range of 18° to 28° C, after ½ hour warm-up.

Weight: approximately 17.5 pounds.

Shipping Weight: approximately 22 pounds.

Dimensions: 16¾" W x 3½" H x 14-5/8" D (cabinet less knob projections 13-1/8" D).

SECTION II

CONTROLS AND CONNECTORS

This section lists the front panel controls and describes their function (see Figure 2 - 1).

2.1 POWER Switch

Applies ac voltage to the primary of the power transformer.

2.2 START/STOP Control

Determines the amplitude point on the output waveform where triggering will start and stop.

2.3 TRIGGER LEVEL Control

Selects the amplitude point on the trigger signal where triggering will occur.

2.4 TRIGGER POLARITY Switch

Determines whether triggering occurs on the negative-going or positive-going edge of the trigger signal.

2.5 MODE Switch (Main Generator)

Selects one of three possible modes of operation. In the NORM position, the output is continuous. In the TRIG position, one cycle of the output waveform occurs for each trigger signal applied, provided the trigger repetition rate does not exceed the frequency setting of the main generator. In the GATE position, the output waveform occurs for the duration of the gate signal.

2.6 FREQUENCY RANGE Switch

Selects one of nine overlapping decade frequency ranges.

2.7 VERNIER Control

Makes fine frequency adjustments (approximately 1% frequency dial range — 2 minor divisions).

When the vernier control is in the CAL position, the output frequency is equal to the product of the frequency dial and range switch setting.

2.8 Frequency Dial

Continuously varies the frequency within the range selected by the FREQUENCY RANGE switch.

2.9 SWEEP DURATION Switch

Enables the sweep generator and selects one of seven available sweep rate ranges. In the OFF position the sweep generator is disabled.

2.10 Sweep Duration Vernier

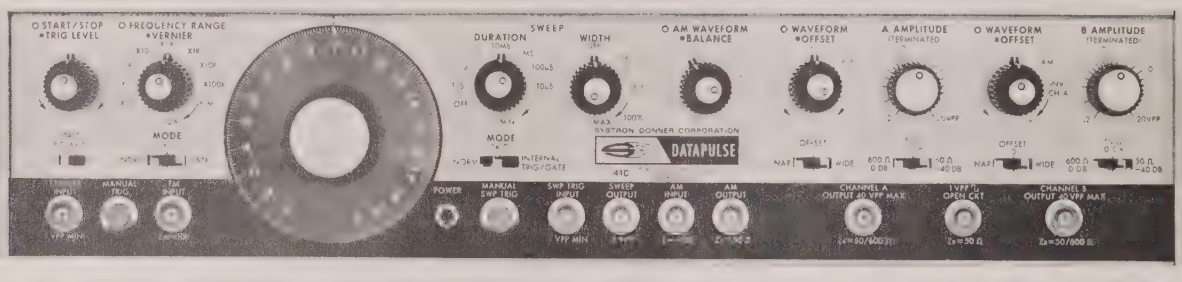
Continuously varies the sweep rate within the range selected by the sweep duration switch.

2.11 SWEEP WIDTH Switch

Determines the percentage of the main generator frequency range to be swept from the dial setting by the sweep generator. In the OFF position the sweep generator continues to operate but is disconnected from the main generator input.

2.12 Sweep Width Vernier

Continuously varies the sweep width within the percentage of the range selected by the SWEEP WIDTH switch (counterclockwise for minimum width).



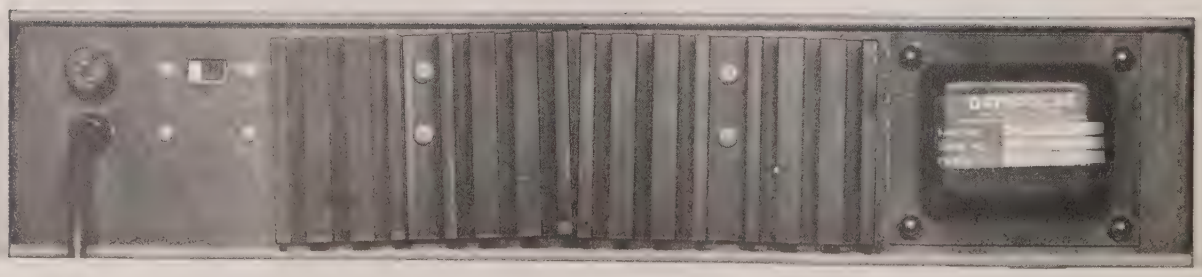


Figure 2-1. Model 410 Controls and Connectors.

2.13 MODE Switch (Sweep Generator)

In the NORM position, the sweep generator continuously sweeps the percentage of the main generator frequency range determined by the width controls, at the rate determined by the duration controls.

In the TRIG position, one cycle of sweep output occurs for each sweep trigger signal applied or each time the MANUAL SWP TRIG pushbutton is depressed.

In the INTERNAL TRIG/GATE position, the sweep output triggers the main generator. The sweep generator is free running in this mode.

2.14 AM WAVEFORM Switch

Selects the waveform to be modulated by an external amplitude modulation signal.

2.15 BALANCE

Adjusts the balance between the positive and negative peaks of the AM waveform.

2.16 WAVEFORM Switch (Channel A)

Selects Channel A output waveform to be either sine (∿), square (⊓), triangle (⋀), inverted sweep (⋁) or amplitude modulated (AM).

2.17 WAVEFORM Switch (Channel B)

Selects Channel B output waveform to be either sine (∿), square (⊓), triangle (⋀), inverted Channel A output (INVCHA) or amplitude modulated (AM).

2.18 AMPLITUDE Control (Channel A and B)

Continuously varies the amplitude of the output waveform from 0.2 to 20 V p–p when terminated with 50 ohms.

2.19 OFFSET Control (Channel A and B)

Continuously adjusts dc level of the output waveform from -20 to +20 volts (see specifications for offset limitations).

2.20 OFFSET Switch (Channel A and B)

In the NAR position, the OFFSET control makes fine dc level adjustments.

In the WIDE position the dc level of the output waveform can be continuously adjusted from -20 to +20 volts.

In the 0 position the dc level of the output waveform is 0 volts.

2.21 600 OHM–0 DB/50 OHM–0 DB/ - 50 OHM–40 DB (Impedance/Attenuator) Switch (Channel A and B)

Selects the output impedance and attenuation.

2.22 MANUAL TRIG Pushbutton

In the triggered or gated mode, one cycle of the selected waveform occurs at the output each time the pushbutton is depressed.

2.23 MANUAL SWP TRIG Pushbutton

In the sweep trigger mode, one cycle of sweep output occurs each time the pushbutton is depressed.

2.24 TRIGGER INPUT

Input connector for an external trigger or gate signal. In the normal mode the main generator can be phase locked to an input to this connector, provided the two frequencies are within approximately 1% of each other.

NOTE: Phase-lock capabilities refer only to instruments with phase-lock modification (see main generator schematic 40000-402).

2.25 FM INPUT

Input connector for a frequency modulation signal.

2.26 SWEEP TRIG INPUT

Input connector for an external sweep trigger.

2.27 SWEEP OUTPUT

Output monitor for the sweep generator.

2.28 AM INPUT

Input for the amplitude modulation signal.

2.29 AM OUTPUT

Output monitor for the amplitude modulated waveform.

2.30 CHANNEL A and B OUTPUT

Output connectors for all waveforms indicated on Channel A and B WAVEFORM switches.

2.31 1 V PP OPEN CKT

Output connector for the 1 volt peak-to-peak square wave calibration signal. The output can also be used as a sync signal.

2.32 115/230 Volt Selector (Back Panel)

Selects the transformer primary configuration for either 115 or 230 volt input.

SECTION III

OPERATION

The following procedure provides a brief operational check of the instrument and an introduction to its controls.

3.1 EQUIPMENT (or equivalent) REQUIRED

a. Real-time oscilloscope with a dual trace plug-in, having a dc to 50 MHz bandwidth capability. Tektronix 546 with a 1A2 plug-in recommended.

b. Trigger and gate source with variable width control. Datapulse 101 Pulse Generator recommended.

c. Two 50 ohm, 5 watt terminations. Tektronix 011 - 0099 - 00 recommended.

d. Two 600 ohm, 5 watt termination.

e. Modulation source with a frequency capability of 1 kHz. Datapulse 401 Function Generator recommended.

3.2 MAIN GENERATOR OPERATION

CAUTION

Verify that the 115/230 volt slide switch on the back panel agrees with the line voltage prior to connecting the power plug.

a. Set the instrument controls as follows:

Control	Setting
FREQUENCY RANGE	X10 K
VERNIER	CAL
Frequency Dial	1
MODE (Main Generator)	NORM
POWER	off (down)
SWEEP DURATION	OFF
SWEEP WIDTH	OFF
CHANNEL A WAVEFORM	sine (∿)
CHANNEL B WAVEFORM	sine (∿)
Channel A AMPLITUDE	fully clockwise
Channel B AMPLITUDE	fully clockwise
Channel A OFFSET switch	0
Channel B OFFSET switch	0
Channel A Attenuator/ Impedance switch	0 DB/ 50 OHM
Channel B Attenuator/ Impedance switch	0 DB/ 50 OHM
Remaining controls	any position

b. Actuate the power switch to the "on" (up) position and verify that the pilot light illuminates.

c. Connect the 1 V PP⊓ connector to the vertical input of the oscilloscope and verify that a square wave of approximately 1 volt peak-to-peak is displayed.

d. Disconnect the 1 V PP⊓ output from the oscilloscope vertical input and connect it to the external trigger input.

Set the oscilloscope for external triggering.

e. Connect CHANNEL A OUTPUT and CHANNEL B OUTPUT to the vertical inputs of the dual-trace oscilloscope. Terminate both with 50 ohms at the oscilloscope.

f. Verify that sine waves of approximately 20 volts peak-to-peak amplitude are displayed on both traces.

g. Rotate both AMPLITUDE controls in a counterclockwise direction and verify that the amplitude of the waveforms decrease accordingly. Return the AMPLITUDE controls to the fully clockwise position.

h. Select the square (⊓), then the triangle (∧) waveform on Channel A and B WAVEFORM switches and verify that the oscilloscope display changes accordingly.

i. Rotate the frequency dial from fully clockwise to fully counterclockwise and verify that the frequency of the displayed waveform changes accordingly.

j. Repeat step (i) for the remaining frequency ranges.

k. Set both AMPLITUDE controls to 1 and both OFFSET switches to WIDE.

l. Rotate both OFFSET controls from - to + and verify that the baselines of the waveforms are shifted from approximately -10 to +10 volts.

m. Set both OFFSET switches to NAR. Rotate both OFFSET controls from - to + and verify that the baselines are shifted from approximately -0.5 to +0.5 volts. Set both OFFSET switches to 0.

n. Rotate both AMPLITUDE controls to the fully clockwise position. Set both attenuator/impedance switches to -40 DB/50 OHM and verify that the amplitude of the displayed waveforms are decreased by a factor of 100.

o. Replace both 50 ohm terminations with 600 ohm terminations. Set both attenuator/impedance switches to 0 DB/600 OHMS and verify that the amplitude of the displayed waveform is approximately 20 volts peak-to-peak.

p. Reconnect the 50 ohm terminations and set the attenuator/impedance switches to 0 DB/50 OHM.

q. Set the Channel B WAVEFORM switch to INVCHA and Channel A WAVEFORM switch to sine (∿). Verify that Channel B output is the inverse of Channel A output.

3.3 SINE SQUARED OPERATION

a. Set the instrument controls the same as in step 3.2a, except set Channel B WAVEFORM switch INVCHA and Channel B AMPLITUDE control for approximately 5 volts peak-to-peak output.

b. Set the AM WAVEFORM switch to sine (∿) and jumper CHANNEL B OUTPUT to the AM INPUT.

c. Connect CHANNEL A OUTPUT and AM OUTPUT to the vertical inputs of the dual trace oscilloscope.

d. Adjust the AM BALANCE for equal peaks on the displayed waveform from the AM OUTPUT. Verify that the frequency of the waveform at the AM OUTPUT is twice that at CHANNEL A OUTPUT and that the amplitude is approximately 0.25 volts.

3.4 PULSE OPERATION

a. Set the instrument controls as follows:

Control	Setting
FREQUENCY RANGE	X0.1 K
VERNIER	CAL
Frequency Dial	1
MODE (Main Generator)	TRIG
SWEEP DURATION	0.1 S
Duration vernier	MIN
SWEEP WIDTH	OFF
SWEEP MODE	INTERNAL TRIG/GATE
Channel A WAVEFORM	square (⊓)
Channel A AMPLITUDE	fully clockwise
Channel A OFFSET switch	0
Channel A Attenuator/ Impedance switch	0 DB/ 50 OHM
Remaining controls	any position

b. Connect CHANNEL A OUTPUT to the oscilloscope vertical input. Terminate with 50 ohms at the oscilloscope.

c. Adjust TRIGGER LEVEL for triggering and verify that a pulse of approximately 20 volts peak-to-peak amplitude, 5 ms width and 10 Hz repetition rate is displayed on the oscilloscope.

d. Verify that the pulse width changes when the main generator frequency dial is varied and that the pulse repetition rate changes when the duration controls are varied (provided the sweep duration is not shorter than the main generator waveform period).

3.5 SWEEP GENERATOR OPERATION

a. Set the instrument controls as follows:

Control	Setting
FREQUENCY RANGE	X10 K
VERNIER	CAL
Frequency Dial	1
MODE (Main Generator)	NORM
SWEEP DURATION	10 MS
SWEEP MODE	NORM
Duration vernier	MIN
SWEEP WIDTH	100%
Width vernier	MAX
Channel A WAVEFORM	inverted sweep (\/)
Channel A AMPLITUDE	fully clockwise
Channel A OFFSET switch	0
Channel A Attenuator/ Impedance switch	0 DB/ 50 OHM
Remaining controls	any position

b. Connect SWEEP OUTPUT and CHANNEL A OUTPUT to the vertical inputs of the dual-trace oscilloscope. Terminate CHANNEL A OUTPUT with 50 ohms at the oscilloscope. Trigger the oscilloscope with the SWEEP OUTPUT.

c. Verify that the repetition rate of the sweep output is approximately 10 Hz

and the amplitude is 5 volts peak-to-peak. Verify that Channel A output is approximately 10 volts peak-to-peak and is the inverse of the sweep output.

d. Rotate the duration vernier in a counterclockwise direction and verify that the sweep duration increases.

e. Select the remaining duration ranges, verifying that the sweep duration changes accordingly and that the duration vernier functions for all ranges.

f. Set the instrument control the same as in step (a), except set Channel A WAVEFORM switch to square (⊓⊔), SWEEP DURATION to 10 S and width vernier to the fully counterclockwise position.

g. Expand the oscilloscope display for approximately 3 cycles of square wave (approximately 0.1 ms).

h. Set the duration vernier to MIN and width vernier to MAX and verify that the period of the square wave decreases from approximately 0.1 to 0.05 ms at a 10 second rate.

NOTE: In steps (i) and (j), set the width verniers to minimum when determining the initial square wave period.

i. Set the FREQUENCY RANGE selector to X1 K and the SWEEP WIDTH switch to 10%. Verify that the period of the square wave decreases from approximately 1 ms to 0.9 ms at a 10 second rate.

j. Set the SWEEP WIDTH to 1% and verify that the period of the square wave decreases from approximately 1 ms to 0.99 ms at a 10 second rate.

3.6 AM and FM OPERATION

a. Set the instrument controls as follows:

Control	Setting
FREQUENCY RANGE	X10 K
VERNIER	CAL
Frequency Dial	1
MODE (Main Generator)	NORM
SWEEP DURATION	OFF
Channel A WAVEFORM	AM
Channel B WAVEFORM	AM
AM WAVEFORM	sine (∿)
AM BALANCE	mid-range
Channel A AMPLITUDE	fully clockwise
Channel B AMPLITUDE	fully clockwise
Remaining controls	any position

b. Set the external modulation source for a 1 kHz, 2 volt peak-to-peak sine wave and connect its output to the AM input. Trigger the oscilloscope from the AM source.

c. Connect the AM OUTPUT to the oscilloscope vertical input and verify that an amplitude modulated sine wave of approximately 0.2 volts peak-to-peak is displayed.

d. Select the other three waveforms on the AM WAVEFORM switch and verify that all can be modulated.

e. Set the AM WAVEFORM switch to sine (∿) and connect CHANNEL A OUTPUT and CHANNEL B OUTPUT to the vertical inputs of the dual-trace oscilloscope. Terminate the OUTPUTS with 50 ohms at the oscilloscope input.

f. Increase the amplitude of the external modulation source to +5 volts peak-to-peak (5 volt sine wave offset by +25 volt dc) and verify that amplitude modulation signals of approximately 20 volts peak-to-peak are displayed. Set the offset of the modulation source to 0 volts dc and verify that the modulated output is a suppressed carrier. Verify that the amplitude is approximately 10 volts peak-to-peak.

g. Verify that the peaks of the modulated waveform can be balanced with the AM BALANCE control.

h. Reduce the amplitude of the external modulation source to 2 volts peak-to-peak and connect it to the FM INPUT.

i. Set WAVEFORM A and WAVEFORM B switches to sine (∿) and verify that Channel A and B outputs are frequency modulated.

3.7 MAIN GENERATOR TRIGGER and GATE OPERATION

a. Set the instrument controls as follows:

Control	Setting
FREQUENCY RANGE	X10 K
VERNIER	CAL
Frequency Dial	1
TRIG POLARITY	+
TRIG SENSITIVITY	mid-range
START/STOP	mid-range
MODE (Main Generator)	TRIG
SWEEP DURATION	OFF
Channel A WAVEFORM	sine (∿)
Channel A OFFSET	0
Channel A AMPLITUDE	fully clockwise
Channel A Attenuator/- Impedance switch	0 DB/- 50 OHM
Remaining controls	any position

b. Trigger the oscilloscope with the 1 V PP⎍output and connect CHANNEL A OUTPUT to one of the vertical inputs. Terminate with 50 ohms at the oscilloscope.

c. Depress MAN TRIG several times and verify that one cycle of sine wave is displayed each time the button is depressed.

d. Set the external trigger source for a 1 kHz repetition rate; 0.5 ms width and a 2 volt peak amplitude. Connect the trigger source to the TRIGGER INPUT and to the other vertical input of the oscilloscope. Trigger the oscilloscope from the trigger source.

e. Verify that the sine wave output is triggered by the leading edge of the trigger signal and that it occurs at the repetition rate of the trigger signal.

f. Set the TRIG POLARITY switch to - and verify that the sine wave output is triggered by the trailing edge of the trigger signal.

g. Set the TRIG POLARITY switch to + and turn the START/STOP control to -. Verify that the displayed waveform has a positive peak of approximately 10 volts and a negative peak of less than 1 volt.

h. Turn the START/STOP control to + and verify that the waveform has a negative peak of approximately -10 volts and a positive peak of less than 1 volt.

i. Rotate the START/STOP control to mid-range and set the MODE switch to GATE. Verify that the sine wave output occurs for the length of time corresponding to the width of the gate signal.

NOTE: The width of the gated output is slightly longer than the gate signal since the last cycle of the waveform will always be completed.

3.8 SWEEP GENERATOR TRIGGER OPERATION

a. Set the instrument controls as follows:

Control	Setting
FREQUENCY RANGE	X10 K
VERNIER	CAL
Frequency Dial	1
MODE (Main Generator)	NORM
SWEEP DURATION	10 S
Duration vernier	MIN
SWEEP WIDTH	100%
Width vernier	MAX
SWEEP MODE	TRIG
Remaining controls	any position

b. Connect the SWEEP OUTPUT to the vertical input of the oscilloscope. Depress the MANUAL SWP TRIG pushbutton several times and verify that the sweep output occurs each time the pushbutton is depressed.

c. Connect the external trigger source to the SWP TRIG INPUT and to the other oscilloscope vertical input. Set the SWEEP DURATION switch to 100 μs.

d. Set the external trigger source to 1 kHz repetition rate, 2 volt amplitude and a 10 μs width. Verify that the sweep output occurs at the repetition rate of the trigger source.

e. Remove the external trigger source and set the SWEEP MODE switch to INTERNAL TRIG/GATE. Set the main generator MODE switch to TRIG and the sweep duration to 1 ms.

f. Monitor CHANNEL A OUTPUT and verify that the output is triggered at the rate of the sweep duration switch setting.

SECTION IV

MAINTENANCE

4.1 PREVENTIVE MAINTENANCE

Proper care and correct use with regularly scheduled inspections provide the best protection against unnecessary repairs and down time. The Datapulse Model 410 is a sensitive laboratory instrument and should not be exposed to severe environmental conditions either in use or in storage. Contaminating or damaging exposure must be avoided at all times if long life and uninterrupted service are expected.

4.1.1 Inspection

Remove the top and bottom covers by removing 2 flat head Phillips screws on each cover. The side panels should normally be left on but may be taken off by removing two screws from the rear end block. Inspect for dirt and corrosion and for loose, broken, or burnt parts and wiring. Circuit board discoloration caused by heat may usually be disregarded unless the instrument is inoperative. Inspection intervals should be based on frequency of use and the severity of the environment to which the instrument is exposed.

4.1.2 Cleaning

Accumulated dust and dirt should be removed as often as required. Use either low velocity dry air or a soft nonmetallic brush to clear the interior of foreign matter. Clean dirty parts with a solvent such as trichlorethylene using a soft cloth, and a cotton tipped applicator for narrow spaces.

4.1.3 Recalibration

The instrument is correctly calibrated when it leaves the factory. However, calibration should be checked at regularly scheduled intervals of either accumulated operating hours or calendar time; 500 operating hours or six month intervals is recommended. Refer to paragraph 4.3 for complete calibration instructions.

4.2 PARTS REPLACEMENT

A procedure should be carefully thought out before a part is removed to avoid unnecessary disassembly and accidental damage. Use only direct replacements for parts affecting performance. Transistors temporarily removed should be returned to their original sockets unless defective. Replacement of some parts will necessitate partial recalibration.

4.2.1 Power Transistors

The power transistors for the dc power supplies and the output amplifier are mounted on the back panel and side rail for heat dissipation. Fiber bushings and mica washers are used to electrically insulate the case (collector) from the heat sink (ground) and a thin film of thermal compound (Wakefield No. 122) is applied to both sides of the mica washers to insure proper thermal conductivity. Incorrectly installed, the transistors may either short out or overheat and fail.

4.2.2 Soldering

Only experienced technicians should replace soldered parts. Printed circuits are vulnerable to excess heat as are many diodes and transistors. The following recommendations should be taken into consideration when replacing soldered parts:

a. Use small diameter rosin core solder and a 35 to 40 watt iron with a wedge

or pointed tip, 1/16 to 1/8 inch wide. The tip must be clean and properly tinned with excess solder removed.

b. Obviously defective parts may be clipped out so their leads can be conveniently unsoldered from the board.

c. Solder only on the circuit side of the board; not on the component side.

d. Apply the tip of the iron directly to the solder joint, at the eyelet, just long enough for the solder to flow.

e. Avoid bringing the iron into contact with the circuit board; overheating will cause the conductor to lift from the board.

f. Use a solder sipper (or some other means) to remove excess solder first when unsoldering a lead, particularly where a lead is bent over, so that it can be straightened before it is pulled out.

g. When a lead is free, clean the hole and remove excess solder, using a solder sipper or a sharp object such as a tooth pick or pointed tool.

h. To prevent heat damage when soldering heat sensitive components, use a heat sink or long nose pliers to grip the lead between the part and the board.

i. Clean the area thoroughly after soldering.

4.3 CALIBRATION

NOTE: To insure maximum performance and long term calibration, no adjustments should be made before a one-half hour warm-up period is complete. Since the warm-up period is to allow for internal temperature stabilization, the instrument top cover should be slid back only while actual adjustments are being made.

4.3.1 Equipment (or equivalent) Required

a. Oscilloscope with a band-pass capability of dc to 50 MHz. Tektronix 546 with a Type 1A2 plug-in recommended.

b. Digital voltmeter capable of reading units of millivolts. Systron-Donner 7000A recommended.

c. Electronic counter capable of reading 2 MHz. Systron-Donner 6150 recommended.

d. Distortion analyzer. Hewlett-Packard 332A recommended.

e. Variable autotransformer.

f. Two fifty ohm, 5 watt terminations. Tektronix 011 - 0099 - 00 recommended.

g. Low voltage dc source capable of 5 volts output.

h. Four 50 ohm coaxial cables terminated with BNC connectors.

i. Pulse generator with a variable width control and 10 kHz repetition rate capability. Datapulse Model 101 recommended.

NOTE: See Figure 4-1 and 4-2 for location of calibration adjustments and test points. Capacitor C1 and C3 are located on the frequency range switch and capacitor C812 is located on the sweep duration switch.

4.3.2 Power Supply Calibration

a. Connect the instrument to the autotransformer.

CAUTION

Verify that the 115/230 volt slide switch on the back panel agrees with the line voltage prior to connecting the power plug.

b. Set the autotransformer for 115 or 230 volts, then actuate the POWER switch.

c. Connect the digital voltmeter between the +15 volts test point and chassis ground. Adjust R31 for +15.0 volts.

d. Vary the line voltage +10%, then -10% and verify that the +15 volt supply does not change more than ±15 millivolts.

e. Connect the digital voltmeter between -15 volt test point and chassis ground and verify a reading of -15 ±0.3 volts.

f. Vary the line voltage +10%, then -10% and verify that the -15 volt supply does not change more than ±15 millivolts.

g. Connect the digital voltmeter between the +30 volt test point and chassis ground and verify a reading of +30 ±0.3 volts.

h. Vary the line voltage +10%, then -10% and verify that the +30 volt supply does not change more then ±30 millivolts.

i. Connect the digital voltmeter between -30 volt test point and chassis ground and verify a reading of -30 ±0.3 volts.

j. Vary the line voltage +10%, then -10% and verify that the -30 volt supply does not change more then ±30 millivolts.

k. Using the oscilloscope, check the ripple on all four power supplies. Vary the line voltage +10% and -10% while making the ripple check. Ripple should not exceed 15 millivolts peak-to-peak.

4.3.3 Square Wave Calibration

a. Set the instrument controls as follows:

Control	Setting
FREQUENCY RANGE	X1
VERNIER	CAL
Frequency Dial	0.1
MODE (Main Generator)	NORM
SWEEP DURATION	OFF
SWEEP WIDTH	OFF
Remaining controls	any position

b. Connect the 1 V PP⊓connector to the input of the digital voltmeter. Set the voltmeter to read dc voltage.

NOTE: Voltmeter reading will shift from +0.5 to -0.5 volts approximately every 5 seconds.

c. Adjust R229 for a positive peak of +0.500 ±0.001 volts and R232 for a negative peak of -0.500 ±0.001 volts.

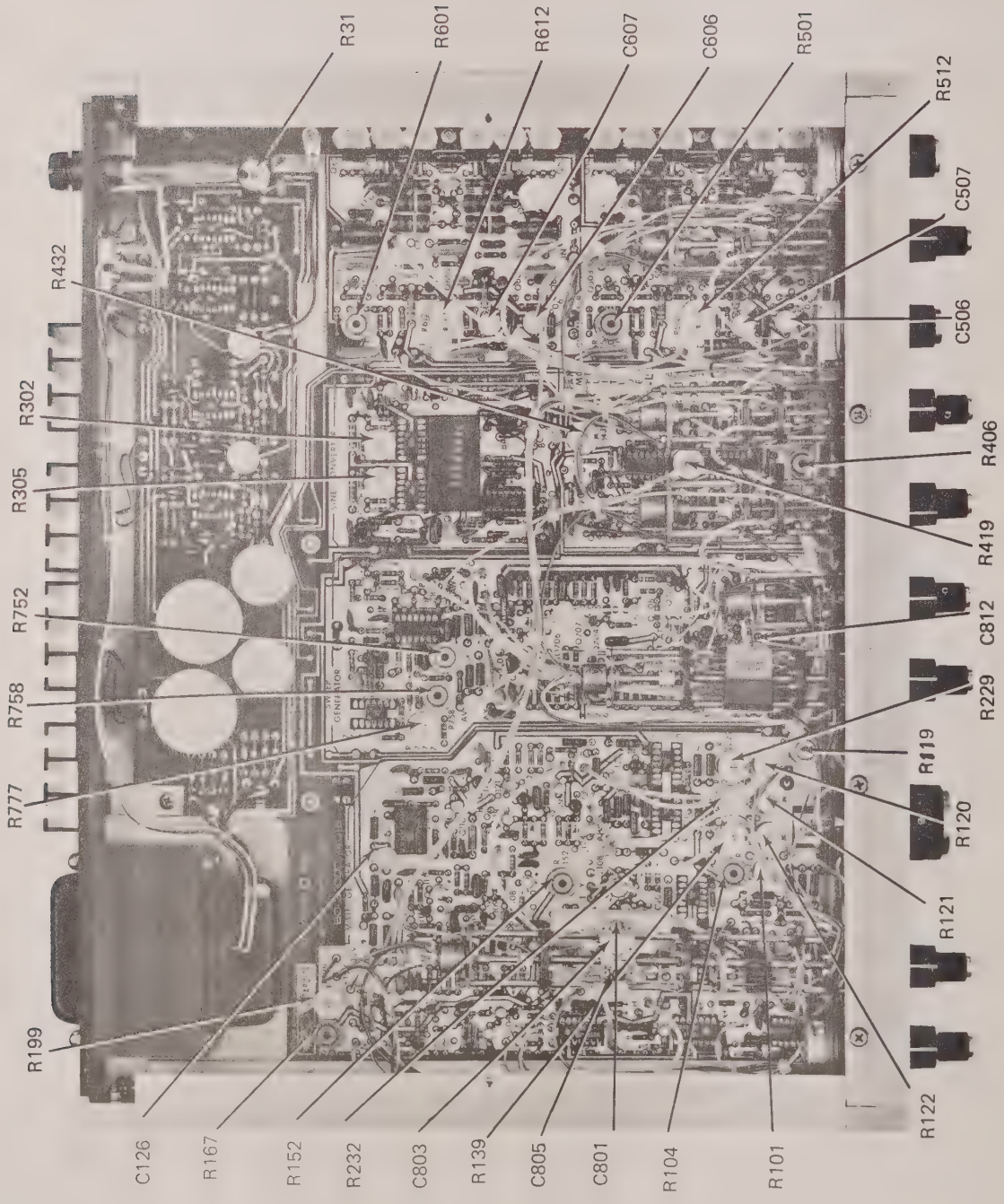


Figure 4-1. Model 410 Top View.

Figure 4-2. Model 410 Bottom View.

d. Set the FREQUENCY RANGE selector to X10 K and the frequency dial to 1.

e. Disconnect the 1 V PP ⏢ from the voltmeter and connect it to the oscilloscope vertical and trigger inputs.

f. Select external triggering on the oscilloscope and set the trigger slope to positive. Set the sweep rate control to display exactly one cycle of square wave.

g. Set the sweep magnifier to X10 and position the square wave so that the negative-going edge is on the center graticule. Set the oscilloscope trigger slope to negative.

NOTE: Do not reposition the square wave with the oscilloscope controls.

h. Adjust R139, if necessary, to reposition the positive-going edge on the center graticule.

i. Switch the oscilloscope trigger slope from negative to positive several times and verify that both edges remain on the center graticule. If readjustment is necessary, always set the trigger slope to negative before adjusting R139.

4.3.4 Sine Wave Distortion Calibration

4.3.4.1 Method I

a. Set the instrument controls as follows:

Control	Setting
FREQUENCY RANGE	X10 K
VERNIER	CAL
Frequency Dial	2
MODE (Main Generator)	NORM
Channel A WAVEFORM	sine (∿)
Channel A OFFSET	0
Channel A Attenuator/ Impedance switch	0 DB/ 50 OHM
Channel A AMPLITUDE	fully clockwise
SWEEP DURATION	OFF
SWEEP WIDTH	OFF
Remaining controls	any position

b. Connect CHANNEL A OUTPUT to the distortion analyzer input. Terminate with 50 ohms at the distortion analyzer.

c. Adjust R302 and R305 for minimum distortion.

d. Set the frequency dial to 0.2 and adjust R152 for minimum distortion.

e. Return the frequency dial to 2 and verify that the distortion is less than 0.25%.

NOTE: After completion of the entire calibration procedure recheck sine wave distortion. Readjust, if necessary.

4.3.4.2 Method II

a. Set the instrument controls the same as in step 4.3.4.1a, except set the frequency dial to 1.

b. Connect TP15 to the oscilloscope vertical input.

c. Using the frequency dial and VERNIER, adjust for minimum signal amplitude on the oscilloscope.

NOTE: TP15 is the output of a notch filter that rejects only 10 kHz, therefore, the oscilloscope display represents sine wave distortion.

d. First adjust R302 and R305 for minimum signal amplitude; then adjust R152 for minimum signal amplitude.

4.3.5 Frequency Range and Dial Calibration

a. Set the instrument controls as follows:

Control	Setting
FREQUENCY RANGE	X1 K
VERNIER	CAL
Frequency Dial	0.2
Channel A WAVEFORM	square (⏊)
Channel A OFFSET	0
Channel A AMPLITUDE	fully clockwise
SWEEP DURATION	OFF
SWEEP WIDTH	OFF
TRIGGER POLARITY	+
TRIGGER LEVEL	+
Remaining controls	any position

NOTE: For instruments with phase-lock modification, a dial accuracy error of approximately 1% will occur if the trigger level and trigger polarity are not in the same sense.

b. Connect CHANNEL A OUTPUT to the counter input. Terminate with 50 ohms at the counter.

c. Adjust the frequency dial for a reading of 5 ±0.05 ms. Loosen the Allen screw on the dial and position the dial to approximately 0.2, then retighten the Allen screw.

d. Set the frequency dial to exactly 0.2 and adjust R104 for 5 ±0.005 ms.

e. Set the frequency dial to 2 and adjust R122 for 2 kHz ±2 Hz.

f. Return the dial to 0.2 and verify a reading of 5 ±0.05 ms. If reading is out of tolerance, repeat step (d) and (e) until both readings are in tolerance.

g. Set the frequency dial at the following positions and verify that readings are within ±1% of the dial setting.

Dial Setting	Frequency
0.2	5 ms ±0.05 ms
0.5	500 Hz ±5 Hz
1	1 kHz ±10 Hz
1.6	1.6 kHz ±16 Hz
2	2 kHz ±20 Hz

h. Set the FREQUENCY RANGE selector to X0.1 K and position the frequency dial to 2. Adjust R121 for a reading of 5 ±0.005 ms.

i. Set the frequency dial at the following positions and verify that the readings are within ±1% of the dial setting.

Dial Setting	Period
0.2	50 ms ±0.5 ms
0.5	20 ms ±0.2 ms
1	10 ms ±0.1 ms
1.6	6.25 ms ±0.06 ms
2	5 ms ±0.05 ms

j. Set the FREQUENCY RANGE selector to X10 and position the frequency dial to 2. Adjust R120 for a reading of 50 ±0.05 ms.

k. Set the frequency dial at the following positions and verify that the readings are within ±1% of the dial setting.

Dial Setting	Period
0.2	500 ms ±5 ms
0.5	200 ms ±2 ms
1	100 ms ±1 ms
1.6	62.5 ms ±0.62 ms
2	50 ms ±0.5 ms

l. Set the FREQUENCY RANGE selector to X1 and position the frequency dial to 2. Adjust R119 for a reading of 500 ±0.5 ms.

m. Set the frequency dial at the following positions and verify that the readings are within ±1% of the dial setting.

Dial Setting	Period
0.2	5 s ±50 ms
0.5	2 s ±20 ms
1	1 s ±10 ms
1.6	62.5 ms ±6.25 ms
2	500 ms ±5 ms

n. Set the FREQUENCY RANGE selector to X10 K and position the frequency dial to 2. Adjust C805 for a reading of 20 kHz ±20 Hz.

o. Set the frequency dial at the following positions and verify that the readings are within ±1% of the dial setting.

Dial Setting	Frequency
0.2	2 kHz ±20 Hz
0.5	5 kHz ±50 Hz
1	10 kHz ±100 Hz
1.6	16 kHz ±160 Hz
2	20 kHz ±200 Hz

p. Set the FREQUENCY RANGE selector to X1 M and position the frequency dial to 0.2. Adjust C801 for a reading of 200 kHz ±2 kHz.

q. Position the frequency dial to 2 and adjust C126 for 2 MHz ±40 kHz.

r. Return the frequency dial to 0.2 and verify that the reading is still in tolerance. If not, repeat step (n) and (o) for a best case in tolerance reading.

s. Set the frequency dial at the following positions and verify that the readings are within ±2% of the dial setting.

Dial Setting	Frequency
0.2	200 kHz ±2 kHz
0.5	500 kHz ±10 kHz
1	1 MHz ±20 kHz
1.6	1.6 MHz ±32 kHz
2	2 MHz ±40 kHz

t. Set the FREQUENCY RANGE selector to X100 K and position the frequency dial to 2. Adjust C803 for a reading of 200 kHz ±2 kHz.

u. Set the frequency dial at the following positions and verify that the readings are within 1% of the dial setting.

Dial Setting	Frequency
0.2	20 kHz ±200 Hz
0.5	50 kHz ±10 kHz
1	100 kHz ±1 kHz
1.6	160 kHz ±1.6 kHz
2	200 kHz ±2 kHz

4.3.6 FM Calibration

a. Set up the equipment and the instrument controls the same as in step 4.3.5 (a) and (b).

b. Connect the low voltage dc source to the FM INPUT. Set the voltage source to 0 volts output.

c. Verify that the counter reads 5 ±0.05 ms.

d. Set the low voltage dc source to 4.5 volts and adjust R101 for a reading of 2 kHz ±1%.

4.3.7 Output Amplifier Calibration

a. Set the instrument controls as follows:

Control	Setting
FREQUENCY RANGE	X10 K
VERNIER	CAL
Frequency Dial	1
SWEEP DURATION	OFF
SWEEP WIDTH	OFF
Channel A WAVEFORM	sine (∿)
Channel B WAVEFORM	sine (∿)
Channel A OFFSET	0
Channel B OFFSET	0
Channel A AMPLITUDE	fully counterclockwise
Channel B AMPLITUDE	fully counterclockwise
Channel A Attenuator/ Impedance switch	50 OHM/ 0 DB
Channel B Attenuator/ Impedance switch	50 OHM/ 0 DB

b. Connect CHANNEL A OUTPUT to the digital voltmeter input. Set the voltmeter to read dc voltage.

c. Adjust R601 for 0.00 volts.

d. Set the voltmeter to read ac voltage. Rotate Channel A AMPLITUDE to the fully clockwise position and adjust R612 for a sine wave amplitude of 14.8 volts rms.

e. Disconnect CHANNEL A OUTPUT from the voltmeter and connect to the vertical input of the oscilloscope. Using the sine wave as a 42 volt peak-to-peak reference, verify that the triangle and square waveforms are greater than 40 volts peak-to-peak.

f. Set the FREQUENCY RANGE selector to X1 M and position the frequency dial to 1. Terminate CHANNEL A OUTPUT with 50 ohms at the oscilloscope.

g. Select the square (⊓) waveform and adjust C606 and C607 for the desired overshoot/rise time compensation.

h. Verify that the rise time is less than 50 ns.

NOTE: Rise time may be adjusted to a higher value if a smoother square wave is desired.

i. Set the FREQUENCY RANGE selector to X10 K and the frequency dial to 1. Set Channel B WAVEFORM to sine (∿).

j. Connect CHANNEL B OUTPUT to the input of the digital voltmeter. Set the voltmeter to read dc voltage. Adjust R501 for 0.00 volts.

k. Set the voltmeter to read ac voltage. Rotate Channel B AMPLITUDE to the

Table 4-1. Dial Accuracy Check.

Dial	Range	Counter Indication
0.2	X0.01	484 s to 516 s
1	X0.01	96 s to 104 s
2	X0.01	49 s to 51 s
0.2	X0.1	41.6 s to 5.84 s
1	X0.1	9.6 s to 10.4 s
2	X0.1	4.9 s to 5.1 s
0.2	X1	4.9 s to 5.1 s
1	X1	980 ms to 1.02 s
2	X1	490 ms to 520 ms
0.2	X10	495 ms to 505 ms
1	X10	99 ms to 101 ms
2	X10	49.5 ms to 50.5 ms
0.2	X0.1 K	49.5 ms to 50.5 ms
1	X0.1 K	9.9 ms to 10.1 ms
2	X0.1 K	4.95 ms to 5.05 ms
0.2	X1 K	4.95 ms to 5.05 ms
1	X1 K	990 Hz to 1010 Hz
2	X1 K	1980 Hz to 2020 Hz
0.2	X10 K	1980 Hz to 2020 Hz
1	X10 K	9.90 kHz to 10.10 kHz
2	X10 K	19.80 kHz to 20.20 kHz
0.2	X100 K	19.80 kHz to 20.20 kHz
1	X100 K	99.90 kHz to 101.0 kHz
2	X100 K	198.0 kHz to 202.0 kHz
0.2	X1 M	196.0 kHz to 204.0 kHz
1	X1 M	980.0 kHz to 1.02 MHz
2	X1 M	1.96 MHz to 2.04 MHz

b. Set the instrument controls as follows:

Control	Setting
FREQUENCY RANGE	X1 K
VERNIER	CAL
Frequency Dial	1
Channel A AMPLITUDE	fully clockwise
Channel A WAVEFORM	sine (∿)
Channel A OFFSET	0
Channel A Attenuator/ Impedance switch	50 OHM/ 0 DB
SWEEP DURATION	OFF
SWEEP WIDTH	OFF
Remaining controls	any position

c. Check several frequencies between 2 Hz and 20 kHz and verify that the distortion is less than 0.25%.

d. Check several frequencies between 20 kHz and 200 kHz and verify that the distortion is less than 0.5%.

e. Check several frequencies between 200 kHz and 600 kHz (distortion analyzer frequency limit) and verify that the distortion is less than 3%.

4.4.4 Symmetry Check

4.4.4.1 Method I

a. Connect CHANNEL A OUTPUT through a tee connector to the B and C inputs of the counter. Set the counter to TIME B—C.

b. Set the Model 410 controls the same as in paragraph 4.4.3 step (b), except set Channel A WAVEFORM switch to square (⊓⊔).

c. Adjust the counter trigger level to input B for positive triggering and set the trigger level to input C for negative triggering. Record the counter indication.

d. Adjust the trigger level to input B for negative triggering and trigger level to input C for positive triggering (set trigger levels equal). Record the counter indication.

e. Verify that the two counter indications are within 0.5% of each other.

f. Check several frequencies up to 200 kHz and verify that the time symmetry is >99.5%.

g. Check several frequencies between 200 kHz and 2 MHz and verify that the time symmetry is >98%.

4.4.4.2 Method II

a. Connect CHANNEL A OUTPUT to the input of the oscilloscope. Terminate with 50 ohms at the oscilloscope.

b. Set the Model 410 controls the same as in paragraph 4.4.3 step (b) except Channel A WAVEFORM switch to square (⊓⊔).

c. Select the delayed sweep on the oscilloscope. Using the delayed sweep multiplier determine the width of the positive and negative halves of the waveform. Verify that the two halves are within 0.5% of each other.

d. Check several frequencies up to 200 kHz and verify that the time symmetry is >99.5%.

e. Check several frequencies between 200 kHz and 2 MHz and verify that the time symmetry is >98%.

4.4.5 Frequency Response Check

a. Set the distortion analyzer to the voltmeter function (or use an rms reading voltmeter with a dB scale). Connect CHANNEL A OUTPUT to the distortion analyzer input. Terminate with 50 ohms at the distortion analyzer.

b. Set the Model 410 controls the same as in paragraph 4.4.3 step (b).

c. Vary the frequency from 10 Hz to 200 kHz and verify that the amplitude does not change more than 1% (0.8 dB).

d. Vary the frequency from 200 kHz to 2 MHz and verify that the amplitude does not change more than 3% (2.4 dB).

NOTE: Voltmeter tolerances must be taken into account.

e. Perform steps (a) through (d) for CHANNEL B OUTPUT.

4.4.6 Square Wave Response Check

a. Connect CHANNEL A OUTPUT to the input of the oscilloscope. Terminate with 50 ohms at the oscilloscope.

b. Set Model 410 controls the same as in paragraph 4.4.3 step (b) except set Channel A WAVEFORM to square (⊓⊔).

c. Verify that the rise and fall times of the square wave (between the 10% and 90% point) are less than 50 ns.

d. Check the rise and fall times of the square wave at several other frequencies to verify that they are less than 50 ns.

e. Verify that the aberrations are less than 5% of the peak-to-peak value of the square wave.

f. Perform steps (a) through (e) for CHANNEL B OUTPUT.

4.4.7 Output Check

a. Set the distortion analyzer to the voltmeter function. Connect CHANNEL A OUTPUT to the input of the distortion analyzer. Terminate with 50 ohms at the distortion analyzer input.

b. Set Model 410 controls the same as in paragraph 4.4.3 step (b).

c. Verify that the amplitude is at least 7.0 V rms. Record the dB reading.

d. Set Channel A AMPLITUDE fully counterclockwise and the Impedance/-Attenuator switch to 50 ohm/-40 dB. Verify that the voltmeter decreases more than 80 dB.

e. Perform step (a) through (d) for CHANNEL B OUTPUT.

4.4.8 External Frequency Control

a. Set the Model 410 controls the same as in paragraph 4.4.3 step (b) except set Channel A WAVEFORM to square (⊓⊔) and VERNIER fully counterclockwise.

b. Connect CHANNEL A OUTPUT to the input of the counter. Connect the low voltage dc source set for 0 volts to FM INPUT.

c. Set the frequency dial to 0.02 (first dial increment) and record the counter indication.

NOTE: If no output is present, rotate dial slightly counterclockwise.

d. Set the low voltage dc source to +5 volts and verify that the frequency increases by a factor of 1000.

4.5 TROUBLESHOOTING

Before assuming that the instrument has a malfunction, double check the control settings and power connections. Verify also that the instrument has been properly calibrated since uncalibrated instruments may often exhibit some of the same symptoms as one that is malfunctioning.

4.5.1 Disassembly Instructions

To gain access to the circuit components and printed circuit board, remove the four flat-head screws (2 in each cover) from the top and bottom covers and slide the covers off. In most situations, it is not necessary to remove the side covers and rails. However, if the need arises, the side covers may be removed by removing the two flat-head screws from the rear end blocks and sliding the side covers off. To remove the side rails, remove the two flat-head screws from the front end blocks, then remove the round head screws (one at each end of the rails) from the upper and lower rails.

4.5.2 General Troubleshooting Instructions

Since the circuitry that generates the triangle and square waveforms is a closed loop (integrator, comparator and squaring circuit), it is often difficult to determine just where the malfunction exists. The function of this paragraph is to set down some general troubleshooting guidelines that will help to localize the malfunction. Usually when the closed loop has a malfunction, no waveforms are present at the output and the output is offset to a dc level of + or -15 volts. If these conditions exist, perform the following steps:

a. Set the FREQUENCY RANGE switch to X10 K and the frequency dial to 2. Verify the voltage at TP2 is approximately +10.8 V and approximately -10.8 V at TP3. If the voltages are present, go to step (b); if not, troubleshoot the frequency control circuit (Z103 through Z106 and associated circuitry).

b. Check the voltage at the input (pin 11 of Z108) and the output (TP6) of the integrator. If the input voltage (approximately + or -1.7 V) and the output voltage (approximately + or -10 V) are opposite polarity, go to step (c). If the input and output are the same polarity or opposite polarity with the output reduced in amplitude (<5 V), the fault is in the integrator (Q105A through Q115).

c. Monitor TP3 with an oscilloscope. Measure the voltage between pin 4 of Z109 and ground with a digital voltmeter and note the polarity. Using a low voltage dc source, apply approximately 1 V dc (the same polarity as noted above) between pin 3 and ground. If the voltage at TP3 shifts levels (positive to negative, or negative to positive) go to step (d); if not, troubleshoot the comparator (Z109 and associated circuitry).

d. If the instrument passes steps (a), (b) and (c), troubleshoot the squaring circuit. For specific problems and their probable causes, see Table 4 - 2.

Table 4-2. Troubleshooting.

Symptom	Probable Cause	Check
1. No output and pilot lamp does not illuminate.	1. No input power, or power supply malfunction.	1. Check line cord connection, fuse and line voltage. If all are correct, troubleshoot the power supply.
2. Pilot lamp illuminated but no waveforms present at output and baseline is at 0 volts.	2. No input from waveform switch or output amplifier is inoperative.	2. Check for waveform at the base of Q1 (output amplifier). If waveform is not present, troubleshoot the waveform switch. If waveform is present, troubleshoot the output amplifier.
3. No waveforms present at output and baseline is + or -15 volts dc.	3. Closed loop consisting of integrator, comparator and squaring circuit.	3. Check the voltage at the input (pin 11 of Z108) and the output (TP6) of the integrator. If the input (+ or -1.7 V) and the output (+ or -10 V) are the same polarity, the integrator is malfunctioning. If the input and output voltages are opposite polarity, but the amplitude at the output is less than 5 volts, check the integrator output transistors Q114 and Q115 and their associated circuitry. For all other cases of integrator input and output voltages, the comparator and/or the squaring circuits are faulty.
4. Sawtooth output in the triangle (∧) position. Very narrow pulses in the square wave (⊓) position.	4. Positive or negative frequency control voltage missing.	4. Check TP7 and TP8 for proper voltage. Check diode bridge network for open diode.
5. All frequency ranges reading high.	5. Open feedback loop to Z104.	5. Check for open diode across terminals 7 and 8 of Z108. Check Q102A/B, Z105 and associated circuitry.
6. Positive and negative peaks of all waveforms unequal and all waveforms unsymmetrical.	6. Z110 or Z111 malfunctioning.	6. Check the supply voltages to Z110 and Z111. If voltages are correct, replace Z110 or Z111.
7. Triangle and square wave present at the output but sine wave is missing.	7. Sine converter or sine amplifier inoperative.	7. Check for correct voltages (approximately 3 volts) at pin 10 of Z301 and Z302. Check the sine shaper output at TP14. If

Table 4-2 (cont.)

		(7) sine wave is not present, replace the sine shaper. If sine wave is present troubleshoot the sine amplifier.
8. Sine wave output distorted.	8. Sine shaper, sine amplifier or output amplifier faulty.	8. Check distortion at TP14. If distortion is >0.18% replace the sine shaper. If not, check the distortion at the output of the sine amplifier. If distortion is >0.25, troubleshoot the sine amplifier; if not, troubleshoot the output amplifier.
9. Sine wave amplitude low but triangle and square waveform amplitude correct.	9. Sine converter or sine amplifier faulty.	9. Check pin 10 of Z301 and Z302 for +3 and -3 volts respectively. Check for a 6 volt sine wave at TP8. If voltage readings are correct, troubleshoot sine amplifier.
10. Amplitudes of all waveforms low.	10. Output amplifier faulty, or square wave input to comparator low.	10. Check waveform amplitudes at the input of the output amplifier. If amplitudes are 10 V p–p, troubleshoot the output amplifier; if not, troubleshoot the squaring circuit.
11. Output continuous when the instrument is in the trigger/gate mode.	11. Trigger/gate circuit or lock-up amplifier inoperative.	11. Check TP5 for presence of trigger pulse. If absent, troubleshoot trigger/gate circuit. If present, troubleshoot the lock-up amplifier.

SECTION V

THEORY OF OPERATION

5.1 GENERAL DESCRIPTION

Refer to Block Diagram 41000 - 224 for the following explanation. Bridge diodes and R1 and R2 reference designations are assigned to facilitate the discussion.

The Model 410 consists of a main generator and a sweep generator. The main generator develops the sine, square and triangle waveforms. The sweep generator develops the ramp waveform and also sweeps the frequency range selected in the main generator.

Frequency dial potentiometer, R819, establishes the level of frequency control voltage at the outputs of amplifiers Z104 and Z106. These two control voltages determine the currents that flow through R1 and R2 to charge and discharge the integrating capacitor. The amount of charging current and the size of integrating capacitor selected determine the output frequency of the main generator.

The triangle and square waveforms are simultaneously developed in the main generator. The linear charging and discharging of the integrating capacitor develop the triangle, which is level-detected by the comparator to develop the square waveform. The comparator output is connected to the junction of bridge diodes CR3 and CR4 and this alternating step voltage is used to steer the charging current to the integrating capacitor.

When the comparator output is negative, CR4 is forward biased and the current through R1 is diverted from the integrating capacitor. Diode CR3 is then reverse biased and the integrating capacitor charges negatively through R2, causing the voltage at the output of the integrator to go positive at a constant rate. When the upper hysteresis point of the comparator is reached by this positive-going voltage, the state of the comparator changes making the junction of CR3 and CR4 positive. The current through R1 then charges the integrating capacitor positively, causing the voltage at the output of the integrator to go negative at a constant rate. When the voltage reaches the lower hysteresis point of the comparator, the state of the comparator changes, making the junction of CR3 and CR4 negative. The time required to charge and discharge the integrating capacitor determines the period of one cycle and therefore the frequency.

The comparator output is also applied to the squaring circuit which utilized complementary differential pairs and stable positive and negative voltage sources to develop an amplified, symmetrical square waveform. A signal of equal amplitude and a 180° phase shift from the square wave output is coupled back to the inverting input of the comparator to establish its hysteresis points.

The sine waveform is developed by shaping the triangle which results in a sine wave of reduced amplitude. A non-inverting amplifier restores the amplitude of the sine wave to that of the applied triangle.

When the instrument is in the trigger or gate mode, the trigger or gate logic circuitry diverts the charging sources from the integrating capacitor. The application of a trigger or gate signal allows the integrating capacitor to charge for the duration of the signal.

The sweep generator output is a linear ramp voltage which is developed by an active integrator and

a comparator similar to those in the main generator. However, the integrating capacitor is allowed to charge only in a positive direction. The time required to charge the integrating capacitor determines the sweep duration and therefore the sweep repetition rate. The duration potentiometer R823 controls the amount of current to the integrating capacitor and functions as a continuous adjustment within the range selected by the duration switch. In the triggered sweep mode the charging current is diverted from the integrating capacitor until the trigger signal is applied.

The amplitude modulation circuit provides for the modulation of the sine, square, triangle and ramp waveforms by an external signal. The heart of the AM circuit is the four-quadrant multiplier which accomplishes the modulation and whose output is the linear product of its two inputs. The multiplier output is amplified by a non-inverting amplifier then fed to the Channel A and B waveform switches and to a front panel connector as the AM OUTPUT.

Frequency modulation is accomplished by applying an external voltage to the FM INPUT. This external voltage is summed with the voltage from the frequency dial potentiometer R819 at the input of amplifier Z103. The change in voltage changes the charging rate of the integrating capacitor which changes the output frequency.

Channel A and B output amplifiers provide final amplification of all output signals.

5.2 DETAILED CIRCUIT DESCRIPTION

5.2.1 Main Generator

Refer to schematic 40000 - 402, Functional Block Diagram, 41000 - 226 and the applicable simplified schematic for the circuit descriptions in paragraph 5.2.1.1 through 5.2.1.6.

5.2.1.1 Frequency Control

Refer to Figure 5 - 1 for the following explanation.

Frequency in the Model 410 is controlled by applying variable positive and negative voltage levels to the range resistors (R805–R809 and R813–R816) and using the resulting current to charge the integrating capacitor (C801 through C810).

The frequency control circuit supplies the voltage levels to the range resistors. Voltages from the frequency dial potentiometer, R824, FM input and/or the sweep generator are summed at the inverting input of operational amplifier Z103. The output of Z103 is coupled to the inverting input of the positive frequency control voltage source Z104, whose output is coupled to the inverting input of the negative frequency control voltage source Z106. Dual FET Q102A/B and Z105 comprise a network to compensate for the 0.6 volt drop across the bridge diode at low integrating currents (X0.01 and X1 ranges). The output of Z105 make the non-inverting input of Z104 approximately 0.6 volts thus increasing the output of Z104 by about 0.6 volts.

The currents developed by the voltage sources and the range resistors are alternately switched to the integrator by the alternating step voltage (comparator output) at the junction of terminals 5 and 11 of Z108. When the step voltage is positive, the diode across terminals 11 and 12 is reverse biased and the integrating capacitor charges positively. When the step voltage is negative, the diode across terminals 5 and 6 is reverse biased and the integrating capacitor charges negatively.

Potentiometers R119 through R122 are gain adjustments for amplifier Z103 on the 2 Hz to 2 kHz ranges respectively. Diodes CR103 and CR104 are for input overvoltage protection and diodes CR108 and CR109 establish a threshold to prevent the bridge from being switched on by spurious signals.

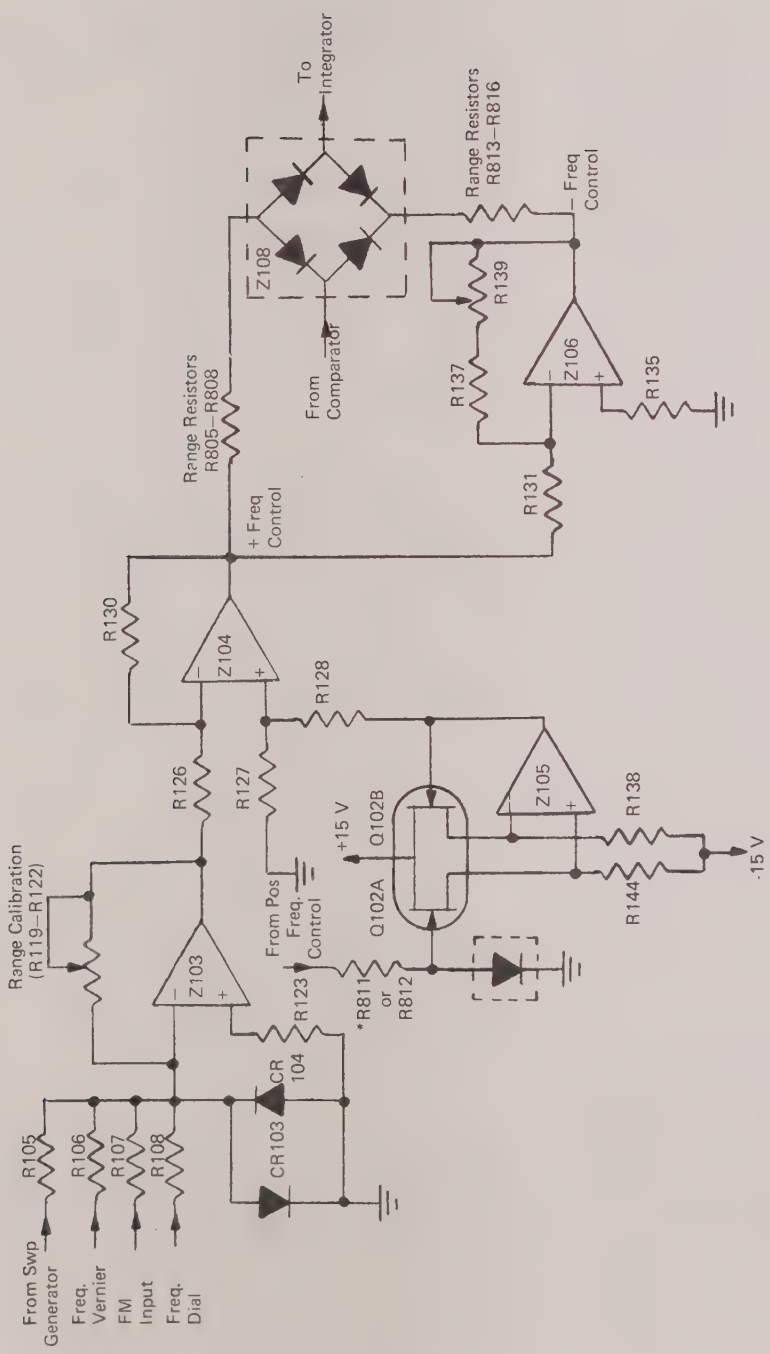


Figure 5-1. Frequency Control.

5.2.1.2 Integrator

The integrator consists of an integrating amplifier and integrating capacitor (C801 through C810). The integrating amplifier is actually two separate amplifiers, one a dc amplifier which is active at the lower frequencies and the other an ac amplifier which takes over at the higher frequencies. Dual FET Q105A/B is the input for the dc amplifier and differential amplifier Q108/Q109 is the input for the ac section. The RC network consisting of C112 and R157 determines the frequency where the shift from the dc to ac amplifier takes place. Capacitors C114 and C116 are roll-off capacitors and potentiometer R152 is the integrator balance which adjust the symmetry of the waveform at the low integrating currents (the low end of the frequency dial). Essentially, the integrating amplifiers is a high gain amplifier whose input draws practically no current. The summing point (between R150 and C112) is held at 0 volts through the feedback path provided by the integrating capacitor (C801 through C810). The amount of current flowing out of or into the amplifier output is determined by the level of the frequency control voltages. Charging and discharging the integrating capacitor develops the triangle waveform.

5.2.1.3 Comparator

The comparator simultaneously level-detects the triangle wave to develop the square wave, compares the amplitude of the triangle and square wave and supplies the alternating step voltage to switch the frequency control bridge.

The inputs to the comparator are the integrator output and the 180° square wave output (see paragraph 5.2.1.4). Resistors R194, R195, R197 and R203 form voltage dividers which limit the input voltages to the comparator. The square wave input to pin 4 of Z109 sets the hysteresis points of the comparator (the points where the comparator output shifts levels) at approximately +1.7 and -1.7 volts.

The output of Z109 is an alternating step voltage of approximately 3.4 volts peak-to-peak (0.35 to +3.05 volts). The baseline of the step voltage is shifted down approximately 1.2 volts by the junction of Q116 and CR121, causing the voltage at the cathode of CR121 to step from -1.6 to +1.6 volts. This step voltage is fed to the frequency control bridge and to the input of the squaring circuit. Capacitors C126 and C127 compensate for the comparator switching time at high frequencies, thus insuring a constant triangle amplitude over the entire frequency range. Emitter follower, Q116 is used for impedance matching.

5.2.1.4 Squaring Circuit

The squaring circuit has two 10 volt peak-to-peak outputs. One output is in phase with the input and the other is 180° out of phase. The 180° output is coupled back to the inverting input of the comparator and the in-phase output is fed to the waveform and AM switches.

The squaring circuit consists of two complementary differential pairs Q119/Q121 and Q120/Q122 which drive complementary output pairs Q116/Q118 and Q123/Q124. The alternating step voltage at the bases of Q119 and Q120 simultaneously turns one transistor on and the other off. Assuming that the step voltage is positive, Q119 is on and Q120 is off, consequently Q121 is off and Q122 is on. With Q119 and Q122 conducting Q118 and Q123 are turned on, causing the collector of Q118 to swing to -5 volts and the collector of Q123 to swing to +5 volts. When the step voltage at the base of Q119 and Q120 is negative the conducting and non-conducting states of the transistors are reversed and the collector of Q116 swings to +5 volts, while the collector of Q124 swings to -5 volts.

Clamp diodes CR122 through CR125 provide over-voltage protection for the bases of output transistors, Q117, Q118, Q123 and Q124. Capacitors C134 and C135 are bypass capacitors and C136 is a roll-off capacitor. Operational amplifiers Z110 and

Z111 provide stable positive and negative 5 volt sources for the output transistors. Potentiometers R230 and R232 are gain adjustments for the amplifiers. Resistors R221 and R222 divide the 10 volt peak-to-peak square wave output.

5.2.1.5 Trigger/Gate Circuit

The trigger/gate circuit consists of differential comparator Z101 and logic circuits Z102 and Z107. This circuit enables the lock-up amplifier which disables the integrator when the instrument is in the trigger or gate mode. Applying a trigger or gate signal disables the lock-up amplifier and enables the integrator.

When the trigger mode is selected, ground is applied through the mode switch to pin 10 of Z107. Assuming that positive slope triggering is selected, the output at pin 8 will be +3 volts. This voltage is applied to the reset input (pin 1) of Z102 and its output (+3 volts) enables the lock-up amplifier. The positive slope of a trigger pulse changes the output at pin 6 of Z102 to 0 volts and the lock-up amplifier is disabled. The comparator output at the base of Q101 insures that the instrument is triggered at the beginning of the waveform.

5.2.1.6 Lock-Up Amplifier

Refer to Figure 5-2 for the following explanation.

The lock-up amplifier by forward-biasing CR110, diverts the charging current from the integrating capacitor when the instrument is in the trigger or gate mode.

During normal operation when the main generator is free running, +15 volts is applied by the mode switch (normal position) to resistor, R198. This voltage forward biases CR119 and reduces the base current to Q113 below the level needed to keep it turned on. With Q113 not conducting, Q104 is off and CR110 is reverse biased.

In the trigger or gate mode, the +3 volt output of Z102 to the cathode of CR118 turns Q113 and Q104 on and forward biases CR110. When the external trigger is applied, Q113 and Q104 are turned off and C110 is reverse biased thus allowing current to flow to the integrating capacitor.

5.2.2 Sine Converter

Refer to schematic 40000 - 404 for the following explanation.

The sine converter is comprised of a sine shaper and a sine amplifier. Its function is to convert the 10 volts peak-to-peak triangle into a 10 volt peak-to-peak sine wave.

The triangle is shaped into 6 volts peak-to-peak sine wave by the sine shaper. Operational amplifiers Z301 and Z302 are voltage sources for the sine shapers. Potentiometers R302 and R305 are gain adjustments for amplifier Z301 and Z302.

The sine amplifier, consisting of Z304 and transistors Q301 through Q304, has a differential input and a push-pull output. The sine amplifier gain is approximately 1.67 therefore the 6 volt peak-to-peak sine wave is amplified to 10 volts. Diodes CR301 and CR302 establish the bias for output transistors Q303 and Q304 and resistors R322 and R323 and feedback resistors for amplifier gain control. Capacitors C309 through C311 and resistors R324, R327 and R328 comprise a 10 kHz notch filter which is used during sine distortion calibration.

5.2.3 Sweep Generator

Refer to the simplified schematic 40000 - 403 and Functional Block Diagram 41000 - 226 for the following explanation.

The operation of the sweep generator is similar to the main generator with the exception that the sweep integrating capacitor (C812 through C817 on the duration switch) is allowed to charge only in

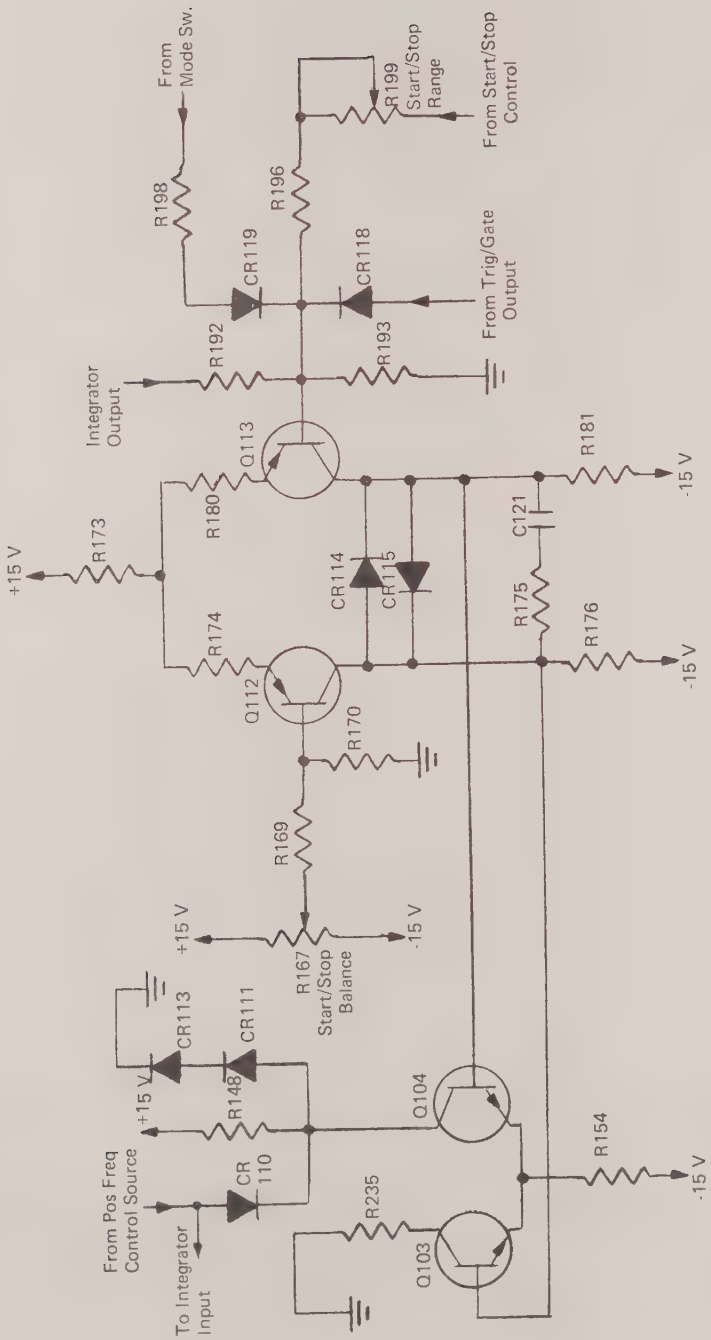


Figure 5-2. Lock-Up Amplifier.

the positive direction. After the capacitor has charged to approximately 10 volts, the output of comparator Z103, taken at the collector of Z712, resets trigger logic R/S flip-flop Z702. The output of Z702 forward biases Q701 and CR708 and the integrating current is diverted through Q701. Transistor Q702 is turned on by the positive-going collector of Q701 and a quick discharge path for the integrating capacitor is provided.

When the sweep mode switch is in the triggered position, the output of Z702 is approximately +3 volts. Diode CR708 and transistor Q701 are forward biased by this voltage and they conduct, diverting the current from the integrating capacitor. An external trigger pulse applied to the input of Z701 changes the output state of Z702 to approximately 0 volts. Diode CR708 is then reverse biased and current flows to the integrating capacitor for the duration of the trigger pulse.

5.2.4 Amplitude Modulation

Refer to schematic 40000 - 405 for the following explanation.

Amplitude modulation is accomplished in the four-quadrant multiplier, Z401. Both the modulating signal and the signal to be modulated are the inputs to Z401. The output of the four-quadrant multiplier is the linear product of the two input voltages multiplied by a factor of 0.1. For example, if the modulating signal is 2 volts and the signal to be modulated is 10 volts, the output of the four-quadrant multiplier is 2 volts.

The modulated signal is amplified by Z402 and coupled to differential amplifier, Q401/-Q402 which drive complementary emitter followers Q403 and Q404. The AM output signal is fed to Channel A and B waveform switches, and divided by R445 and R446 and coupled to a front panel connector at the AM output.

Diodes CR401 and CR402 provide input over-voltage protection for the four-quadrant multiplier. Diodes CR403 and CR404 establish the bias levels for the output emitter followers. Feedback for the amplifier is taken through the RC network consisting of C410 through C412 and resistors R428 and R430 through R434.

5.2.5 Output Amplifier

Refer to schematic 40000 - 406 for the following explanation.

The Model 410 has two independent output amplifiers. Since the operation of the two amplifiers are identical, only Channel A output will be explained.

The output amplifier has a gain of 4 and provides final amplification for all of the output waveforms. Offset is supplied at the amplifier summing point (the junction of R602, R603 and R604) by offset control R833.

The input stage of the output amplifier consists of complementary differential pairs, Q601/Q604 and Q602/Q605. These differential amplifiers alternately supply emitter current to amplifiers Q603 and Q604 which in turn supply base current to drivers Q607 and Q608. Emitter follower Q609 and Q610 drive parallel complementary emitter followers Q611 through Q614.

Diodes CR601 through CR604 establish the bias levels for transistors Q607 and Q608. The overall amplifier gain is controlled through the feedback network consisting of R605 through R612 and C606 through C609. Capacitors C606 and C607 are high frequency compensation adjustments.

5.2.6 Power Supply

Refer to schematic 40000 - 401 for the following explanation.

The power supply consists of four series regulators; positive and negative 30 volts and positive and negative 15 volts. The positive and negative 30 volt regulator are identical with the exception that

the +30 volt regulator is referenced to the +15 volt supply and the -30 volt regulator is referenced to the +30 volt supply. Both 15 volt regulators are identical with the exception that the +15 volt regulator is referenced by zener diode CR17 and the -15 volt regulator is referenced through R39 to the +15 volt supply. Basically, the operation of the four regulators are the same, therefore only the +30 volt regulator will be explained.

Any error between the reference voltage and the voltage at the junction of R43 and R44 is amplified by Z3. This amplified error signal causes a change in current through the high gain series pass transistors (Q5 and Q6) to correct for the error.

Over-current protection is provided by transistors Q1 and Q11. During normal operation, both transistors are off. However when an over-current condition occurs, Q11 is forward biased by the voltage drop across diode CR15 and parallel resistors R34 and R35. This causes Q11 to conduct and the excess current is shunted around series pass transistors Q5 and Q6.

SECTION VI

PARTS LIST

6.1 ABBREVIATIONS and SYMBOLS

6.1.1 Reference Designations

Reference designations in this parts list correspond to the circuit symbols used in the following schematics:

Drawing Number 40000-401
Drawing Number 40000-402
Drawing Number 40000-403
Drawing Number 40000-404
Drawing Number 40000-405
Drawing Number 40000-406
Drawing Number 40000-407

6.1.2 Abbreviations

ampere	A
capacitor	C
diode	CR
double pole	dp
fuse	F
indicator lamp	DS
jack	J
kilohm	k
megohm	M
microfarad	μF
peak inverse voltage	piv
picofarad	pF
resistor	R
single pole-double throw	SPDT
switch	S
transformer	T
transistor	Q
variable	VAR
volts	V
watts	W
integrated circuit	Ƶ

6.1.3 Manufacturers

Allen Bradley Company	AB
ACDC Electronics	ACDC
American Components Incorporated	ACI
American Radionics Incorporated	Amer. Rad.
Amphenol RF Division	Amphenol
Arco Electronics Incorporated	Arco
Astrodyne Incorporated	Astrodyne
Buckeye Stamping Company	Buckeye
Bussman Manufacturing Company	Buss
Centralab Electronics Division	Centralab
Continental Wirt	CW
C & K Components	C&K
Corning Glass Works	Corning
Datapulse Division of Systron-Donner Corporation	DP
Duncan Electronics Incorporated	Duncan
ElectroMotive Manufacturing Company	Elmenco
Erie Technological Products Company	Erie
Fairchild Semiconductor Products Incorporated	FT
Motorola Semiconductor Products Incorporated	Mot.
Nashville Electronic Corporation	Nashville
National Semiconductor Corporation	National
Oak Manufacturing Company	Oak
Pacific Electricord Company	Electricord
Radio Corporation of America	RCA

Rodan Incorporated	Rodan	Switchcraft Incorporated	Switchcraft
Sangamo Electric Company	Sangamo	Sylvania Electric Products Incorporated	Syl.
Siliconix Incorporated	Siliconix	Texas Instruments	TI
Sprague Electric Company	Sprague	Westinghouse Electric Corporation	West.
STM Corporation	STM		

6.2 FRONT PANEL ASSEMBLY

REF. NO.	DATAPULSE PART NO.	QTY. USED	DESCRIPTION	MFR.	MFR. PART NO.
C811	11077-220	2	22 pF, 500 V, 5%	Arco	DM15E220J
C819			Same as C811		
J801	15050-000	9	Connector, BNC	Amphenol	667-2 31-221
J802 thru J809			Same as J801		
R801	20123-103	2	Dual concentric, 10 k, X10 k, 2 W, 10%, var.	AB	JJC96098
R802			Same as R801		
R804	10010-105	2	1 M, ¼ W, 5%	AB	CB1055
R817	10010-100	1	10 ohms, ¼ W, 5%	AB	CB1005
R818			Same as R804		
R819	10344-102	1	1 k, 4 W, 5%	Duncan	1630
R832	10010-154	2	150 k, ¼ W, 5%	AB	CB1545
R839	20043-501	2	500 ohms, 2 W, 10%, var.	AB	JA1N056S501AA
R840	10011-209	2	2 ohms, ½ W, 5%	AB	EB20G5
R841	10750-551	2	550 ohms, ¼ W, 1%	TI	CR¼ RN60D
R842	10750-502	2	4.99 k, ¼ W, 1%	TI	CR¼ RN60D
R843	10710-499	2	49.9 ohms, ¼ W, 1%	Corning	NA60
R844			Same as R832		
R851			Same as R839		
R852			Same as R840		
R853			Same as R841		
R854			Same as R842		
R855			Same as R843		
S1	15280-019	1	Toggle, SPDT	C&K	7101PHB
S801	15310-002	1	Slide, SPDT	CW	G124
S802	15300-001	2	Pushbutton, non-locking	Switchcraft	903-1C-Red
S804	15310-001	6	Slide, DP 3 pos.	CW	G128S
S805			Same as S802		
S806			Same as S804		
S810			Same as S804		
S812			Same as S804		
S813			Same as S804		
S815			Same as S804		
DS801	15450-044	1	Indicator Light	Rodan	BFA14-Grn
	B33000-261	1	Dial		

REF. NO.	DATAPULSE PART NO.	QTY. USED	DESCRIPTION	MFR.	MFR. PART NO.
	15400-037	7	Knob	Buckeye	70CC-2
	15400-035	2	Knob	Buckeye	PS-70D-2
	15400-034	7	Knob	Buckeye	PS50D-2
6.3	BACK PANEL ASSEMBLY				
F1	15470-030	1	1A, 250 V, slow blow	Buss	MDL-1
Q3	12666-000	1	NPN, 2N4921	Mot.	2N4921
Q4	12616-000	1	PNP, 2N4918	Mot.	2N4918
Q5	12616-001	1	PNP, MJE2955	Mot.	MJE2955
Q8	12666-001	1	NPN, MJE3055	Mot.	MJE3055
S2	B15310-003	1	Slide, 115/230 V	CW	G626 Modif.
T1	C24010-031	1	Power	ACDC	
	C15550-141	2	Heat Sink	Astrodyne	2501-360-A00
	17130-006	1	Line Cord, Power		
	15470-002	1	Fuse Holder	Buss	AGX-1
6.4	WAVEFORM SWITCH ASSEMBLY				
	Channel A				
R834	10010-331	5	330 ohms, ¼ W, 5%	AB	CB3315
R835			Same as R834		
R836			Same as R834		
R837			Same as R834		
R838			Same as R834		
R839	10091-103	1	10 k, ½ W, 20%	AB	WA4N056S103MA
S81	A25260-018	1	Rotary	Oak	AAMD
	A32001-242	1	Coupling	DP	
	B33000-262	1	Support, Coax Cable	DP	
	Channel B				
R846	10010-331	5	330 ohms, ¼ W, 5%	AB	CB3315
R847			Same as R846		
R848			Same as R846		
R849			Same as R846		
R850			Same as R846		
R851	10091-103	1	10 k, ½ W, 20%	AB	WA4N056S103MA
S814	A25260-018	1	Rotary	Oak	AAMD
	A33000-262	1	Support, Coax Cable	DP	
	A32001-242	1	Coupling	DP	

6.5 AM WAVEFORM SWITCH ASSEMBLY

REF. NO.	DATAPULSE PART NO.	QTY. USED	DESCRIPTION	MFR.	MFR. PART NO.
R827	10010-331	4	330 ohms, ¼ W, 5%	AB	CB3315
R828			Same as R827		
R829			Same as R827		
R830			Same as R827		
R831	10091-103	1	10 k, ½ W, 20%, var.	AB	WA4N056S103MA
	A32001-242	1	Coupling	DP	
	B33000-262	1	Support, Coax Cable	DP	

6.6 SWEEP WIDTH SWITCH ASSEMBLY

R824	10091-103	1	10 k, ½ W, 20%, var.	AB	WA4N056S103MA
R825	10750-903	1	90 k, ¼ W, 1%	TI	CR¼, RN60D
R826	10714-904	1	900 k, ¼ W, 1%	TI	RN65D
S808	A25250-050	1	Rotary	Oak	AAMD
	A32001-242	1	Coupling	DP	

6.7 FREQUENCY RANGE SWITCH ASSEMBLY

C801	11313-200	2	1.5–20 pF, var.	Arco	402
C802	11017-390	2	39 pF, 500 V, 5%	Sangamo	DR1439
C803			Same as C801		
C804			Same as C802		
C805	11313-350	1	3–30 pF, var.	Arco	403
C806	11005-471	1	470 pF, 300 V, 1%	Sangamo	RR-06347F
				Elmenco	CM-15E-471F
C807	11224-502	1	0.005 μF, 200 V, 2%	Amer. Rad.	MPW2502G
C808	11224-503	1	0.05 μF, 200 V, 2%	Amer. Rad.	MPW2503G
C809	11224-504	1	0.5 μF, 200 V, 2%	Amer. Rad.	MPW2504G
C810	11214-505	1	5 μF, 200 %, 5%	Amer. Rad.	MPW2505J
R803	20053-103	1	10 k, 2 W, 10%, var.	AB	JA1N056S103UA
R805	10710-502	2	4.99 k, 1%, ¼ W	Corning	RN60D
R806	10780-503	2	50 k, 1/8 W, 0.1%	ACI	EE1/8, RN60C
R807	10780-504	2	500 k, 1/8 W, 0.1%	ACI	RN60C
R808	10650-505	2	4.99 M, ¼ W, 1%	Dale	RN10X
R809	10010-515	1	5.1 M, ¼ W, 5%	AB	CB5155
R813			Same as R805		
R814			Same as R806		
R815			Same as R807		
R816			Same as R808		
S803	A25250-049	1	Rotary	Oak	AMD
	B33000-269	1	Bracket, switch	DP	
	A32001-242	1	Coupling	DP	

6.8 PRINTED CIRCUIT BOARD ASSEMBLY

REF. NO.	DATAPULSE PART NO.	QTY. USED	DESCRIPTION	MFR.	MFR. PART NO.
R1	10010-100	15	10 ohms, ¼ W, 5%	AB	CB1005
R2	10011-109	10	1 ohm, ½ W, 5%	AB	EB10G5
R3			Same as R2		
R4			Same as R2		
R5			Same as R2		
R6	10010-103	20	10 k, ¼ W, 5%	AB	CB1035
R7			Same as R6		
R8	10010-101	19	100 ohms, ¼ W, 5%	AB	CB1015
R9			Same as R8		
R10	10010-510	5	51 ohms, ¼ W, 5%	AB	CB5105
R11			Same as R10		
R12	10010-102	20	1 k, ¼ W, 5%	AB	CB1025
R13			Same as R12		
R14	10010-391	7	390 ohms, ¼ W, 5%	AB	CB3915
R15	10010-682	4	6.8 k, ¼ W, 5%	AB	CB6825
R16			Same as R15		
R17			Same as R14		
R18			Same as R10		
R19			Same as R10		
R20			Same as R2		
R21			Same as R2		
R22			Same as R14		
R23			Same as R6		
R24			Same as R6		
R25			Same as R14		
R26	10010-512	9	5.1 k, ¼ W, 5%	AB	CB5125
R27	10010-821	1	820 ohms, ¼ W, 5%	AB	CB8215
R28	10710-103	15	10 k, ¼ W, 1%	Corning	NA60
R29			Same as R28		
R30	10710-362	2	3.57 k, ¼ W, 1%	Corning	NA60
R31	10437-102	11	1 k, ¼ W, 20%, var.	AB	FR102M
R32	10690-562	1	5.62 k, 1/8 W, 1%, var.	Corning	RN60C
R33	10010-330	2	33 ohms, ¼ W, 5%	AB	CB3305
R34	10011-159	4	1.5 ohms, ½ W, 5%	AB	EB15G5
R35			Same as R34		
R36			Same as R34		
R37			Same as R34		
R38			Same as R33		
R39	10750-303	2	30 k, ¼ W, 1%	TI	CR¼, RN60D
R40			Same as R28		
R41			Same as R12		

REF. NO.	DATAPULSE PART NO.	QTY. USED	DESCRIPTION	MFR.	MFR. PART NO.
R42			Same as R12		
R43			Same as R28		
R44			Same as R28		
R45			Same as R28		
R47			Same as R39		
R48			Same as R28		
R49	10010-562	2	5.6 k, ¼ W, 5%	AB	CB5625
R50	10011-562	1	5.6 k, ½ W, 5%	AB	EB5625
R51			Same as R49		
R101			Same as R31		
R102	10023-103	1	10 k, 2 W, 10%	AB	HB1031
R103			Same as R12		
R104	10437-103	10	10 k, ¼ W, 20%	AB	FR103M
R105	10710-502	3	4.99 k, ¼ W, 1%	Corning	NA60
R106	10010-135	1	1.3 M, ¼ W, 5%	AB	CB1355
R107	10750-952	2	9.53 k, ¼ W, 1%	TI	CR¼, RN60D
R108	10750-273	1	27.4 k, ¼ W, 1%	TI	CR¼, RN60D
R109	10010-275	1	2.7 M, ¼ W, 5%	AB	CB2755
R110			Same as R6		
R111	10750-153	1	15 k, ¼ W, 1%	TI	CR¼, RN60D
R112			Same as R6		
R113			Same as R6		
R114	10010-392	9	3.9 k, ¼ W, 5%	AB	CB3925
R115			Same as R114		
R116	10750-452	1	4.53 k, ¼ W, 1%	TI	CR¼, RN60D
R118			Same as R12		
R119			Same as R104		
R120	10439-202	5	2 k, ½ W, 10%	AB	SV2021
R121			Same as R120		
R122			Same as R120		
R123	10010-123	1	12 k, ¼ W, 5%	AB	CB1235
R124	10010-561	4	560 ohms, ¼ W, 5%	AB	CB5615
R125	10010-683	1	68 k, ¼ W, 5%	AB	CB6835
R126			Same as R28		
R127			Same as R28		
R128			Same as R28		
R129			Same as R6		
R130			Same as R28		
R131			Same as R28		
R132			Same as R6		
R133			Same as R6		
R134			Same as R6		
R135			Same as R26		

REF. NO.	DATAPULSE PART NO.	QTY. USED	DESCRIPTION	MFR.	MFR. PART NO.
R136			Same as R114		
R137			Same as R107		
R138	10010-823	2	82 k, ¼ W, 5%	AB	CB8235
R139			Same as R31		
R140			Same as R114		
R141			Same as R114		
R142			Same as R12		
R143			Same as R114		
R144			Same as R138		
R145	10010-100	14	10 ohm, ¼ W, 5%	AB	CB1005
R146			Same as R6		
R147			Same as R6		
R148	10010-472	5	4.7 k, ¼ W, 5%	AB	CB4725
R149			Same as R26		
R150	10010-104	4	100 k, ¼ W, 5%	AB	CB1045
R151	10010-203	4	20 k, ¼ W, 5%	AB	CB2035
R152			Same as R104		
R153	10010-393	2	39 k, ¼ W, 5%	AB	CB3935
R154			Same as R12		
R155			Same as R151		
R156			Same as R150		
R157	10010-303	4	30 k, ¼ W, 5%	AB	CB3035
R158	10010-182	4	1.8 k, ¼ W, 5%	AB	CB1825
R159			Same as R148		
R160	10010-151	4	150 ohms, ¼ W, 5%	AB	CB1515
R161	10010-272	2	2.7 k, ¼ W, 5%	AB	CB2725
R162	10010-560	5	56 ohms, ¼ W, 5%	AB	CB5605
R163	10010-120	3	12 ohms, ¼ W, 5%	AB	CB1205
R164			Same as R160		
R165			Same as R162		
R166			Same as R158		
R167			Same as R104		
R168			Same as R157		
R169	10010-332	3	3.3 k, ¼ W, 5%	AB	CB3325
R170	10010-181	1	180 ohms, ¼ W, 5%	AB	CB1815
R171	10010-569	9	5.6 ohms, ¼ W, 5%	AB	CB56G5
R172	10010-201	2	200 ohms, ¼ W, 5%	AB	CB2015
R173	10010-911	2	910 ohms, ¼ W, 5%	AB	CB9115
R174			Same as R8		
R175			Same as R145		
R176			Same as R12		
R177	10010-751	11	750 ohms, ¼ W, 5%	AB	CB7515
R178	10010-681	6	680 ohms, ¼ W, 5%	AB	CB6815
R179			Same as R171		

REF. NO.	DATAPULSE PART NO.	QTY. USED	DESCRIPTION	MFR.	MFR. PART NO.
R180			Same as R8		
R181			Same as R12		
R182	10010-220	10	22 ohms, ¼ W, 5%	AB	CB2205
R183			Same as R182		
R184	10010-150	9	15 ohms, ¼ W, 5%	AB	CB1505
R185			Same as R184		
R186			Same as R182		
R187			Same as R182		
R188	10010-820	1	82 ohms, ¼ W, 5%	AB	CB8205
R189	10710-501	15	499 ohms, ¼ W, 1%	Corning	NA60
R190			Same as R189		
R191			Same as R189		
R192			Same as R12		
R193	10010-221	6	220 ohms, ¼ W, 5%	AB	CB2215
R194			Same as R189		
R195	10750-101	4	100 ohms, ¼ W, 1%	TI	CR¼, RN60D
R196	10010-302	7	3 k, ¼ W, 5%	AB	CB3025
R197			Same as R195		
R198			Same as R12		
R199			Same as R31		
R200			Same as R124		
R201			Same as R145		
R202			Same as R8		
R203			Same as R189		
R204			Same as R8		
R205			Same as R8		
R206	10010-331	6	330 ohms, ¼ W, 5%	AB	CB3315
R207	10011-102	3	1 k, ½ W, 5%	AB	EB1025
R208			Same as R8		
R209	10010-202	11	2 k, ¼ W, 5%	AB	CB2025
R210			Same as R209		
R211			Same as R177		
R212			Same as R177		
R213			Same as R162		
R214			Same as R177		
R215			Same as R177		
R216			Same as R209		
R217			Same as R209		
R218			Same as R8		
R219	10011-511	3	510 ohms, ½ W, 5%	AB	EB5115
R220			Same as R219		
R221			Same as R189		
R222	10750-550	2	55.5 ohms, ¼ W, 1%	TI	CR¼, RN60D

REF. NO.	DATAPULSE PART NO.	QTY. USED	DESCRIPTION	MFR.	MFR. PART NO.
R223			Same as R161		
R224			Same as R189		
R225			Same as R189		
R226			Same as R189		
R227			Same as R161		
R228			Same as R28		
R229			Same as R31		
R230			Same as R105		
R231			Same as R105		
R232			Same as R31		
R233			Same as R28		
R234			Same as R6		
R235			Same as R8		
R236			Same as R12		
R237	10010-105	3	1 M, ¼ W, 5%	AB	CB1055
R238			Same as R12		
R301	10010-223	3	22 k, ¼ W, 5%	AB	CB2235
R302			Same as R120		
R303			Same as R148		
R304			Same as R148		
R305			Same as R120		
R306			Same as R301		
R307	10011-681	2	680 ohms, ½ W, 5%	AB	EB6815
R308			Same as R114		
R309			Same as R114		
R310			Same as R307		
R311			Same as R178		
R312			Same as R12		
R313			Same as R184		
R314	10010-222	2	2.2 k, ¼ W, 5%	AB	CB2225
R315			Same as R178		
R316			Same as R12		
R317	10010-752	3	7.5 k, ¼ W, 5%	AB	CB7505
R318			Same as R206		
R319			Same as R206		
R320			Same as R317		
R321			Same as R314		
R322			Same as R30		
R323	10710-202	1	2 k, ¼ W, 1%	Corning	RN60D, NA60
R324	10750-163	1	15.9 k, ¼ W, 1%	TI	CR¼, RN60D
R325	10010-241	2	240 ohms, ¼ W, 5%	AB	CB2415
R326	10010-390	1	39 ohms, ¼ W, 5%	AB	CB3905
R327	10750-323	2	31.8 k, ¼ W, 1%	TI	CR¼, RN60D

REF. NO.	DATAPULSE PART NO.	QTY. USED	DESCRIPTION	MFR.	MFR. PART NO.
R328			Same as R327		
R329	10010-152	5	1.5 k, ¼ W, 5%	AB	CB1525
R330			Same as R182		
R331			Same as R184		
R332			Same as R184		
R333			Same as R182		
R334			Same as R189		
R335			Same as R189		
R336			Same as R189		
R337			Same as R237		
R338			Same as R237		
R401	10013-512	1	5.1 k, 2 W, 5%	AB	HB5125
R402	10010-273	1	27 k, ¼ W, 5%	AB	CB2735
R403			Same as R209		
R404			Same as R196		
R405			Same as R206		
R406			Same as R104		
R407			Same as R196		
R408			Same as R209		
R409			Same as R12		
R410			Same as R6		
R411			Same as R12		
R412	10010-471	6	470 ohms, ¼ W, 5%	AB	CB4715
R413			Same as R412		
R414			Same as R169		
R415			Same as R169		
R416	10010-122	2	1.2 k, ¼ W, 5%	AB	CB1225
R417			Same as R209		
R418			Same as R196		
R419			Same as R31		
R420			Same as R178		
R421			Same as R178		
R422			Same as R209		
R423			Same as R196		
R424			Same as R12		
R425			Same as R317		
R426			Same as R26		
R427			Same as R163		
R428	10010-511	8	510 ohms, ¼ W, 5%	AB	CB5115
R429			Same as R26		
R430			Same as R416		
R431			Same as R206		
R432			Same as R31		

REF. NO.	DATAPULSE PART NO.	QTY. USED	DESCRIPTION	MFR.	MFR. PART NO.
R433			Same as R12		
R434			Same as R428		
R435			Same as R325		
R436			Same as R329		
R437			Same as R171		
R438			Same as R171		
R439			Same as R184		
R440			Same as R184		
R441			Same as R171		
R442			Same as R171		
R443			Same as R189		
R444			Same as R189		
R445			Same as R189		
R446			Same as R222		
R501			Same as R104		
R502	10010-334	2	330 k, ¼ W, 5%	AB	CB3345
R503			Same as R196		
R504			Same as R12		
R505			Same as R177		
R506			Same as R177		
R507			Same as R14		
R508	10012-241	4	240 ohma, 1 W, 5%	AB	GB2415
R509			Same as R412		
R510			Same as R428		
R511			Same as R508		
R512			Same as R31		
R513			Same as R145		
R514			Same as R145		
R515	10011-332	4	3.3 k, ½ W, 5%	AB	EB3325
R516			Same as R515		
R517			Same as R8		
R518			Same as R145		
R519			Same as R145		
R520			Same as R8		
R521			Same as R428		
R522			Same as R428		
R523			Same as R412		
R524			Same as R145		
R525	10010-121	4	120 ohms, ¼ W, 5%	AB	CB1215
R526			Same as R525		
R527			Same as R182		
R528			Same as R193		
R529			Same as R193		

REF. NO.	DATAPULSE PART NO.	QTY. USED	DESCRIPTION	MFR.	MFR. PART NO.
R530			Same as R2		
R531	10011-100	8	10 ohms, ½ W, 5%	AB	EB1005
R532			Same as R531		
R533			Same as R2		
R534			Same as R531		
R535			Same as R531		
R536	10723-510	8	51 ohms, 2 W, 5%	Corning	MIL-RL42S510J
R537			Same as R207		
R538			Same as R536		
R540			Same as R536		
R541			Same as R536		
R601			Same as R104		
R602			Same as R502		
R603			Same as R196		
R604			Same as R12		
R605			Same as R177		
R606			Same as R177		
R607			Same as R14		
R608			Same as R508		
R609			Same as R412		
R610			Same as R428		
R611			Same as R508		
R612			Same as R31		
R613			Same as R145		
R614			Same as R145		
R615			Same as R515		
R616			Same as R515		
R617			Same as R8		
R618			Same as R145		
R619			Same as R145		
R620			Same as R8		
R621			Same as R428		
R622			Same as R428		
R623			Same as R412		
R624			Same as R145		
R625			Same as R525		
R626			Same as R525		
R627			Same as R182		
R628			Same as R193		
R629			Same as R193		
R630			Same as R2		
R631			Same as R531		
R632			Same as R531		

REF. NO.	DATAPULSE PART NO.	QTY. USED	DESCRIPTION	MFR.	MFR. PART NO.
R633			Same as R2		
R634			Same as R531		
R635			Same as R531		
R636			Same as R536		
R637			Same as R207		
R638			Same as R536		
R639			Same as R209		
R640			Same as R536		
R641			Same as R536		
R642			Same as R178		
R701			Same as R209		
R702	10022-103	1	10 k, 1 W, 10%	AB	GB1031
R703			Same as R6		
R704			Same as R12		
R705	10010-333	1	33 k, ¼ W, 5%	AB	CB3335
R706			Same as R124		
R707			Same as R15		
R708			Same as R12		
R709			Same as R15		
R710			Same as R12		
R711			Same as R6		
R712			Same as R26		
R713			Same as R6		
R714			Same as R26		
R715			Same as R12		
R716			Same as R12		
R717	10010-153	2	15 k, ¼ W, 5%	AB	CB1535
R718			Same as R717		
R719			Same as R145		
R720			Same as R329		
R721	10010-154	1	150 k, ¼ W, 5%	AB	CB1545
R723			Same as R151		
R724			Same as R150		
R725			Same as R153		
R726			Same as R104		
R727			Same as R151		
R728			Same as R150		
R729			Same as R157		
R730			Same as R158		
R731			Same as R160		
R732			Same as R162		
R733			Same as R161		
R734			Same as R148		

REF. NO.	DATAPULSE PART NO.	QTY. USED	DESCRIPTION	MFR.	MFR. PART NO.
R735			Same as R160		
R736			Same as R162		
R737			Same as R158		
R738			Same as R157		
R739			Same as R163		
R740			Same as R171		
R741			Same as R172		
R742			Same as R171		
R743			Same as R329		
R744			Same as R329		
R745			Same as R171		
R746			Same as R184		
R747			Same as R184		
R748			Same as R182		
R749			Same as R182		
R750			Same as R195		
R751			Same as R195		
R752			Same as R104		
R753	10750-102	4	1 k, ¼ W, 1%	TI	CR¼, RN60D
R754			Same as R753		
R755			Same as R26		
R756			Same as R753		
R757			Same as R753		
R758			Same as R104		
R759			Same as R173		
R760			Same as R8		
R761			Same as R301		
R762			Same as R8		
R763			Same as R124		
R764			Same as R8		
R765			Same as R10		
R766			Same as R206		
R767			Same as R12		
R768			Same as R8		
R769			Same as R177		
R770			Same as R177		
R771			Same as R209		
R772			Same as R8		
R773			Same as R219		
R774			Same as R14		
R775			Same as R114		
R776			Same as R6		
R777			Same as R26		

REF. NO.	DATAPULSE PART NO.	QTY. USED	DESCRIPTION	MFR.	MFR. PART NO.
R778			Same as R26		
R779			Same as R193		
C1	11162-408	2	4000μF, 50 V	STM	23C50HA43
C2			Same as C1		
C3	11161-358	2	3500μF, 25 V	STM	23C25TA352
C4			Same as C3		
C5	11241-223	65	0.022μF, 25 V	Sprague	HY525
C6			Same as C5		
C7	11491-226	14	22μF, 20 V, 20%	Sprague	196D
C8			Same as C7		
C9	11166-107	6	100μF, 35 V	Mallory	MTV100DE35
C10			Same as C9		
C101	11077-101	3	100 pF, 500 V, 5%	Arco	DM15E101J
C102			Same as C5		
C103			Same as C5		
C104	11077-509	7	5 pF, 500 V, 10%	Arco	DM10-050K
C105			Same as C5		
C106			Same as C5		
C107			Same as C5		
C108			Same as C5		
C109	11077-221	3	220 pF, 500 V, 5%	Arco	DM15-221J
C110			Same as C5		
C111			Same as C5		
C112	11073-102	4	1000 pF, 100 V, 5%	Arco	DM15E102J
C113	11077-680	2	68 pF, 500 V, 5%	Arco	DM15E680J
C114			Same as C112		
C115			Same as C5		
C116			Same as C5		
C117			Same as C5		
C118			Same as C5		
C119			Same as C5		
C120			Same as C5		
C121	11077-220	4	22 pF, 500 V, 5%	Arco	DM15E220J
C122			Same as C7		
C123			Same as C5		
C124			Same as C5		
C125			Same as C7		
C126	11309-600	1	15–60 pF, 200 V	Erie	538-011-E2PO-94R
C127	11077-470	5	47 pF, 500 V, 5%	Arco	DM15E470J
C128			Same as C113		
C129			Same as C5		
C130	11077-100	6	10 pF, 500 V, 5%	Arco	DM15E100J
C131			Same as C5		

REF. NO.	DATAPULSE PART NO.	QTY. USED	DESCRIPTION	MFR.	MFR. PART NO.
C132			Same as C5		
C133			Same as C5		
C134			Same as C5		
C135			Same as C5		
C136	11077-330	3	33 pF, 500 V, 5%	Arco	DM15E330J
C137			Same as C5		
C138			Same as C5		
C139			Same as C7		
C140			Same as C7		
C141			Same as C130		
C142			Same as C130		
C143			Same as C130		
C144	11242-104	25	0.1 μF, 75 V	Centralab	DDA104
C145			Same as C130		
C301			Same as C5		
C302			Same as C5		
C303			Same as C7		
C304			Same as C7		
C305			Same as C5		
C306			Same as C5		
C307	11079-102	4	1000 pF, 100 V, 1%	Arco	DM15-102F
C308			Same as C121		
C309	11079-501	2	500 pF, 500 V, 1%	Arco	DM15-501F
C310			Same as C307		
C311			Same as C309		
C312			Same as C127		
C313			Same as C5		
C314			Same as C5		
C315			Same as C7		
C316			Same as C7		
C317			Same as C127		
C318			Same as C127		
C319			Same as C127		
C401			Same as C5		
C404			Same as C5		
C405			Same as C5		
C406			Same as C5		
C407			Same as C5		
C408			Same as C5		
C409			Same as C307		
C410			Same as C130		
C411			Same as C104		
C412	11077-150	1	15 pF, 500 V, 5%	Arco	DM15-150J

REF. NO.	DATAPULSE PART NO.	QTY. USED	DESCRIPTION	MFR.	MFR. PART NO.
C413			Same as C5		
C414			Same as C7		
C415			Same as C5		
C416			Same as C7		
C501			Same as C5		
C502			Same as C144		
C503			Same as C144		
C504			Same as C144		
C505			Same as C144		
C506	11307-110	4	2.5–11 pF, var.	Erie	538-014-90B
C507			Same as C506		
C508			Same as C121		
C509			Same as C136		
C510			Same as C5		
C511			Same as C144		
C512			Same as C104		
C513			Same as C144		
C514			Same as C104		
C515			Same as C144		
C516			Same as C144		
C517			Same as C144		
C518			Same as C109		
C519			Same as C144		
C520			Same as C9		
C521			Same as C9		
C522			Same as C144		
C523			Same as C5		
C601			Same as C5		
C602			Same as C144		
C603			Same as C144		
C604			Same as C144		
C605			Same as C144		
C606			Same as C506		
C607			Same as C506		
C608			Same as C121		
C609			Same as C136		
C610			Same as C5		
C611			Same as C144		
C612			Same as C104		
C613			Same as C144		
C614			Same as C104		
C615			Same as C144		
C616			Same as C144		

REF. NO.	DATAPULSE PART NO.	QTY. USED	DESCRIPTION	MFR.	MFR. PART NO.
C617			Same as C144		
C618			Same as C109		
C619			Same as C144		
C620			Same as C9		
C621			Same as C9		
C622			Same as C144		
C623			Same as C5		
C701			Same as C104		
C702			Same as C5		
C703			Same as C5		
C704			Same as C109		
C705			Same as C109		
C706			Same as C5		
C707			Same as C5		
C708			Same as C5		
C709			Same as C144		
C710			Same as C5		
C711			Same as C5		
C712			Same as C112		
C713			Same as C5		
C714			Same as C5		
C715			Same as C5		
C716			Same as C307		
C717			Same as C5		
C718			Same as C144		
C719			Same as C7		
C720			Same as C5		
C721			Same as C5		
C722			Same as C112		
C723			Same as C5		
C724			Same as C101		
C725			Same as C101		
C726			Same as C5		
C727	11077-390	1	39 pF, 500 V, 5%	Arco	DM15E390J
C728			Same as C5		
C729			Same as C130		
C730			Same as C5		
C731			Same as C5		
C732			Same as C5		
C733			Same as C7		
C734	11077-561	1	560 pF, 500 V	Arco	DM15F561J
CR1	S22194-001	12	DP19-1, 100 V, 1A	West.	359B
				TI	1N4005

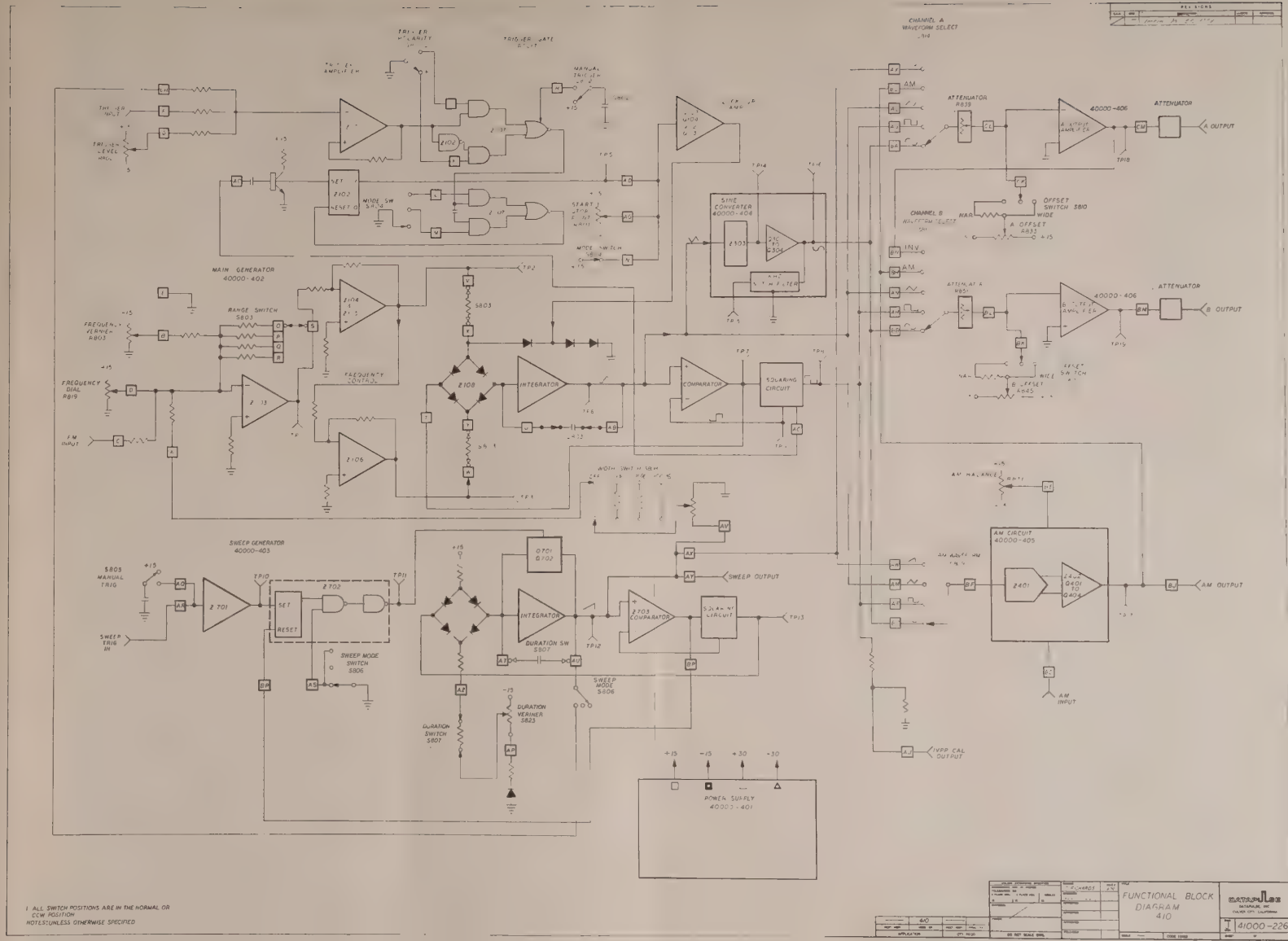
REF. NO.	DATAPULSE PART NO.	QTY. USED	DESCRIPTION	MFR.	MFR. PART NO.
CR2			Same as CR1		
CR3			Same as CR1		
CR4			Same as CR1		
CR5			Same as CR1		
CR6			Same as CR1		
CR7			Same as CR1		
CR8			Same as CR1		
CR9	22314-200	2	1N968B, 20 V, 400 mW, 5%	Mot.	1N968B
CR10			Same as CR9		
CR11			Same as CR1		
CR12			Same as CR1		
CR13	S22164-000	47	DP16-0, 40 V	FT	FD6282
CR14			Same as CR13		
CR15			Same as CR1		
CR16			Same as CR1		
CR17	12154-201	1	1N936, 9 V, 0.5 W, 5%	Mot.	1N936
CR101			Same as CR13		
CR102			Same as CR13		
CR103			Same as CR13		
CR104			Same as CR13		
CR105	22314-100	3	1N758A, 10 V, 400 mW, 5%	Semcor	1N758A
CR106	22314-919	4	1N757A, 9.1 V, 400 mW, 5%	Mot.	1N757A
CR107			Same as CR105		
CR108			Same as CR13		
CR109			Same as CR13		
CR110			Same as CR13		
CR112			Same as CR13		
CR114			Same as CR13		
CR115			Same as CR13		
CR116			Same as CR13		
CR117	12144-003	5	15 piv, 30 mA, 1N995	Syl.	1N995
CR118			Same as CR13		
CR119			Same as CR13		
CR120			Same as CR106		
CR121			Same as CR13		
CR122			Same as CR13		
CR123			Same as CR13		
CR124			Same as CR13		
CR125			Same as CR13		
CR301			Same as CR13		
CR302			Same as CR13		
CR401			Same as CR13		
CR402			Same as CR13		

REF. NO.	DATAPULSE PART NO.	QTY. USED	DESCRIPTION	MFR.	MFR. PART NO.
CR403			Same as CR13		
CR404			Same as CR13		
CR501			Same as CR13		
CR502			Same as CR117		
CR503			Same as CR117		
CR504			Same as CR13		
CR601			Same as CR13		
CR602			Same as CR117		
CR603			Same as CR117		
CR604			Same as CR13		
CR701			Same as CR13		
CR702			Same as CR13		
CR703			Same as CR106		
CR704			Same as CR105		
CR705 thru CR716			Same as CR13		
CR717			Same as CR106		
CR718			Same as CR13		
CR719			Same as CR13		
CR720			Same as CR13		
Q1	12605-017	11	PNP, MPS U55	Mot.	MPS U55
Q2	12645-020	12	NPN, MPS U05	Mot.	MPS U05
Q3	12666-000	1	NPN, 2N4921	Mot.	2N4921
Q4	12616-000	1	PNP, 2N4918	Mot.	2N4918
Q5	12616-001	1	PNP, MJE2955	Mot.	MJE2955
Q6			Same as Q1		
Q7			Same as Q2		
Q8	12666-001	1	NPN, MJE3055	Mot.	MJE3055
Q9	12645-016	10	NPN, MPS6515	Mot.	MPS6515
Q10	12605-018	25	PNP, MPS6519	Mot.	MPS6519
Q11			Same as Q2		
Q12			Same as Q1		
Q101	22635-003	11	NPN, DP633	Mot.	SM4785
Q102AB	12715-000	3	N, U235, Dual Fet	Siliconix	U235
Q103			Same as Q101		
Q104			Same as Q101		
Q105AB			Same as Q102AB		
Q106			Same as Q10		
Q107			Same as Q10		
Q108			Same as Q10		
Q109			Same as Q10		
Q110	12645-013	4	NPN, 2N5179	RCA	2N5179
Q111			Same as Q110		
Q112			Same as Q10		

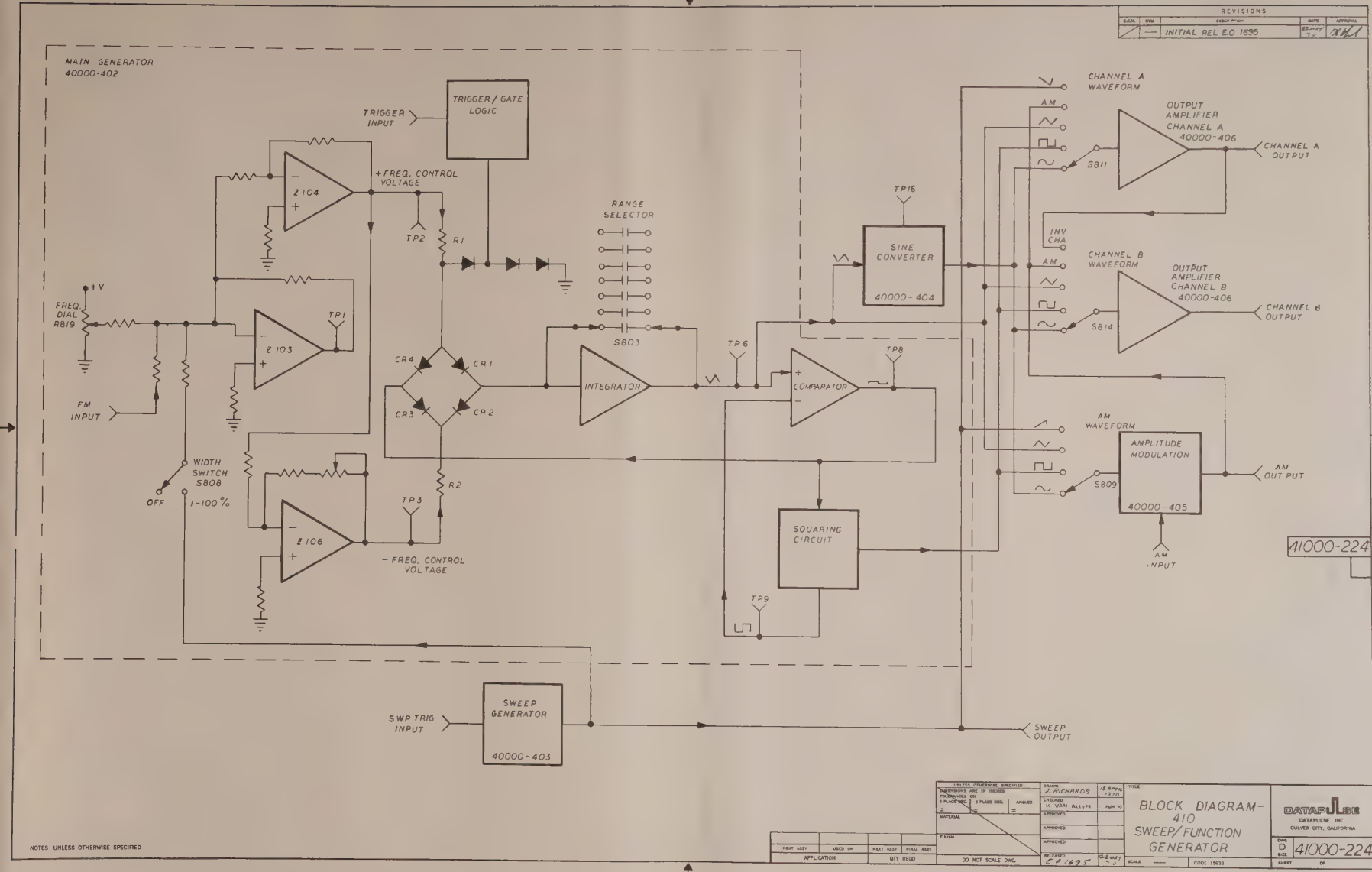
REF. NO.	DATAPULSE PART NO.	QTY. USED	DESCRIPTION	MFR.	MFR. PART NO.
Q113			Same as Q10		
Q114			Same as Q9		
Q115			Same as Q10		
Q116			Same as Q101		
Q117	12605-012	6	PNP, 2N4258	FT	2N4258
Q118			Same as Q101		
Q119			Same as Q101		
Q120			Same as Q117		
Q121			Same as Q101		
Q122			Same as Q117		
Q123			Same as Q117		
Q124			Same as Q101		
Q301			Same as Q10		
Q302			Same as Q10		
Q303			Same as Q9		
Q304			Same as Q10		
Q401			Same as Q10		
Q402			Same as Q10		
Q403			Same as Q9		
Q404			Same as Q10		
Q501			Same as Q9		
Q502			Same as Q10		
Q503			Same as Q9		
Q504			Same as Q9		
Q505			Same as Q10		
Q506			Same as Q10		
Q507			Same as Q1		
Q508			Same as Q2		
Q509			Same as Q2		
Q510			Same as Q1		
Q511			Same as Q2		
Q512			Same as Q1		
Q513			Same as Q2		
Q514			Same as Q1		
Q601			Same as Q9		
Q602			Same as Q10		
Q603			Same as Q9		
Q604			Same as Q9		
Q605			Same as Q10		
Q606			Same as Q10		
Q607			Same as Q1		
Q608			Same as Q2		
Q609			Same as Q2		

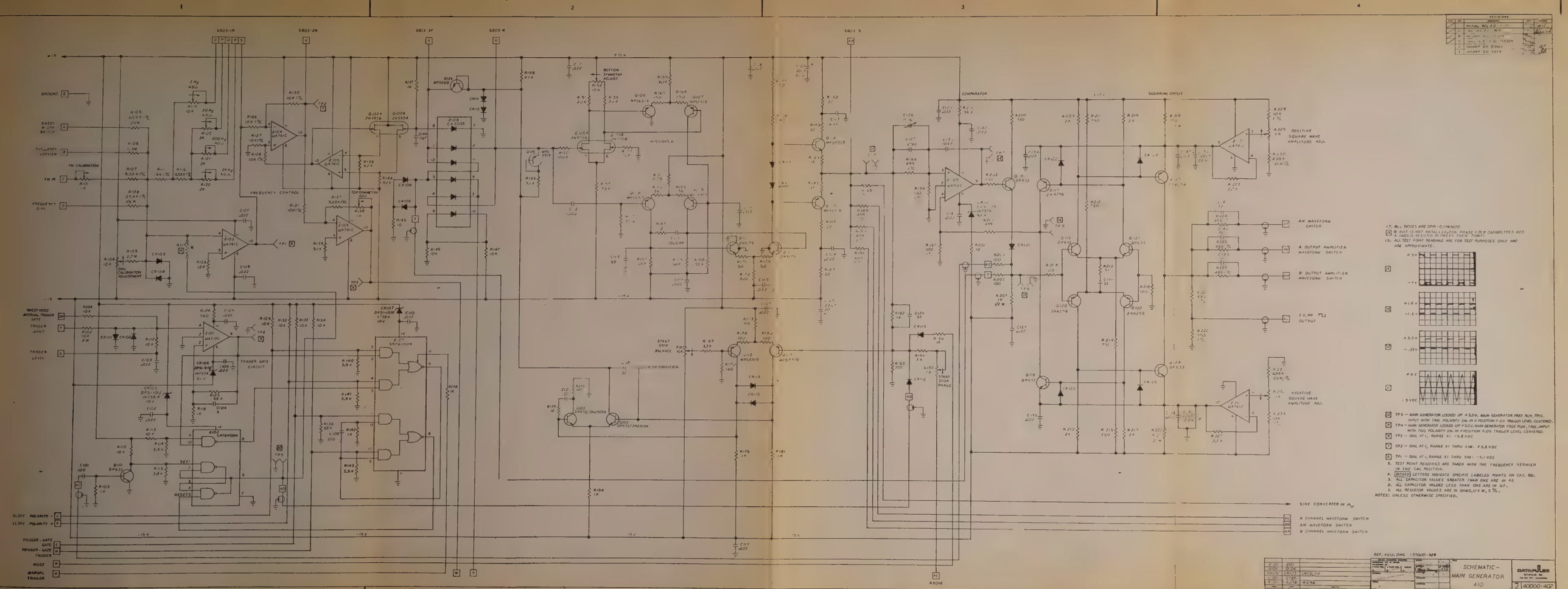
REF. NO.	DATAPULSE PART NO.	QTY. USED	DESCRIPTION	MFR.	MFR. PART NO.
Q610			Same as Q1		
Q611			Same as Q2		
Q612			Same as Q1		
Q613			Same as Q2		
Q614			Same as Q1		
Q701			Same as Q117		
Q702	12715-001	1	FET, 2N5555	Mot.	2N5555
Q703AB			Same as Q102AB		
Q704			Same as Q10		
Q705			Same as Q10		
Q706			Same as Q10		
Q707			Same as Q10		
Q708			Same as Q110		
Q709			Same as Q110		
Q710			Same as Q2		
Q711			Same as Q10		
Q712			Same as Q101		
Q713			Same as Q101		
Q714			Same as Q101		
Q715			Same as Q117		
Z1	12903-000	13	IC, UA741C, Linear OP Amp	FT	μA741C
Z2			Same as Z1		
Z3			Same as Z1		
Z4			Same as Z1		
Z101	12903-002	4	IC, UA710C, Diff. Comparator	FT	μA710C
Z102	12923-000	2	IC, SN74HOON, Nand Gate	TI	SN74HOON
Z103			Same as Z1		
Z104			Same as Z1		
Z105			Same as Z1		
Z106			Same as Z1		
Z107	12923-004	1	IC, SN74H50N, Inverter Gate	National	LM302
Z108	12903-005	1	IC, CA3039, Diode Array	RCA	CA3039
Z109			Same as Z101		
Z110			Same as Z1		
Z111			Same as Z1		
Z301			Same as Z1		
Z302			Same as Z1		
Z303	37000-903	1	Sine Shaper	DP	
Z304	12903-006	2	IC, CA3046, Transistor Array	RCA	CA3046
Z401	12903-007	1	IC, MC1495, 4 Quad Multiplier	Mot.	MC1495
Z402			Same as Z304		
Z701			Same as Z101		
Z702			Same as Z102		

REF. NO.	DATAPULSE PART NO.	QTY. USED	DESCRIPTION	MFR.	MFR. PART NO.
Z703			Same as Z101		
Z704			Same as Z1		
6.9	SWEEP DURATION SWITCH ASSEMBLY				
C812	11313-200	1	1.5–20 pF	Arco	402
C813	11017-820	1	82 pF, 1%	Sangamo	RR1482
C814	11027-102	1	0.001 μF, 1%	Sangamo	CR1210
C815	11025-103	1	0.01 μF, 1%	Sangamo	CR1110F
C816	11124-104	1	0.1 μF, 1%	Electrocube	210B1C104F
C817	11124-105	1	1 μF, 1%	Electrocube	210B1C105F
C818	11241-223	1	0.022 μF, 25 V	Sprague	HY525
R820	10010-102	1	1 k, ¼ W, 5%	AB	CB1025
R821	10010-135	1	1.3 M, ¼ W, 5%	AB	CB1355
R822	10010-136	1	13 M, ¼ W, 5%	AB	CB1365
R823	10091-103	1	10 k, 20%, ½ W	AB	WA4N056S103MA
S807	A25250-051	1	7 position Rotary Switch	DP	



1 ALL SWITCH POSITIONS ARE IN THE NORMAL OR CCW POSITION
NOTES:UNLESS OTHERWISE SPECIFIED


REVISIONS
INITIAL REL E.O 1695
MAIN GENERATOR
40000-402
TRIGGER INPUT
TRIGGER / GATE LOGIC
+FREQ. CONTROL VOLTAGE
Z 104
TP2
R1
RANGE SELECTOR
S803
+V
FREQ. DIAL R819
Z 103
TP1
FM INPUT
CR4
CR1
CR3
CR2
INTEGRATOR
TP6
COMPARATOR
TP8
WIDTH SWITCH S808
OFF
1-100%
R2
TP3
Z 106
- FREQ. CONTROL VOLTAGE
SQUARING CIRCUIT
TP9
TP16
SINE CONVERTER
40000-404
CHANNEL A WAVEFORM
AM
OUTPUT AMPLIFIER CHANNEL A
40000-406
S811
CHANNEL A OUTPUT
INV CHA
CHANNEL B WAVEFORM
OUTPUT AMPLIFIER CHANNEL B
40000-406
S814
CHANNEL B OUTPUT
AM WAVEFORM
AMPLITUDE MODULATION
40000-405
S809
AM OUTPUT
AM INPUT
41000-224
SWP TRIG INPUT
SWEEP GENERATOR
40000-403
SWEEP OUTPUT
NOTES UNLESS OTHERWISE SPECIFIED
UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON
3 PLACE DEC.
3 PLACE DEC.
ANGLES
MATERIAL
FINISH
DO NOT SCALE DWG.
DRAWN J. RICHARDS
CHECKED K. VAN ALLYN
APPROVED
RELEASED E.O 1695
TITLE
BLOCK DIAGRAM-410
SWEEP/FUNCTION GENERATOR
DATAPULSE, INC.
CULVER CITY, CALIFORNIA
DWG SIZE D
41000-224
SCALE
CODE 15933
SHEET
OF
NEXT ASSY
USED ON
NEXT ASSY
FINAL ASSY
APPLICATION
QTY REQD



17. ALL DIODES ARE DPS-0/1N3600
16. ⊛ BUIT IS NOT INSTALLED FOR PHASE LOCK CAPABILITIES ADD A 1MEG/1% RESISTOR BETWEEN THESE POINTS
15. ALL TEST POINT READINGS ARE FOR TEST PURPOSES ONLY AND ARE APPROXIMATE.

TP5 — MAIN GENERATOR LOCKED UP +3.3V. MAIN GENERATOR FREE RUN; TRIG. INPUT WITH TRIG POLARITY SW. IN + POSITION +.0V TRIGGER LEVEL CENTERED.

TP4 — MAIN GENERATOR LOCKED UP +3.3V; MAIN GENERATOR FREE RUN; TRIG. INPUT WITH TRIG POLARITY SW. IN + POSITION +.0V TRIGGER LEVEL CENTERED.

TP3 — DIAL AT 1, RANGE X1. -5.8 VDC

TP2 — DIAL AT 1, RANGE X1 THRU X1M. +5.8 VDC

TP1 — DIAL AT 1, RANGE X1 THRU X1M: -5.1 VDC

5. TEST POINT READINGS ARE TAKEN WITH THE FREQUENCY VERNIER IN THE CAL POSITION.
4. BOXED LETTERS INDICATE SPECIFIC LABELLED POINTS ON CKT. BD.
3. ALL CAPACITOR VALUES GREATER THAN ONE ARE IN PF.
2. ALL CAPACITOR VALUES LESS THAN ONE ARE IN UF.
1. ALL RESISTOR VALUES ARE IN OHMS, 1/4 W, ± 5%.

NOTES: UNLESS OTHERWISE SPECIFIED.

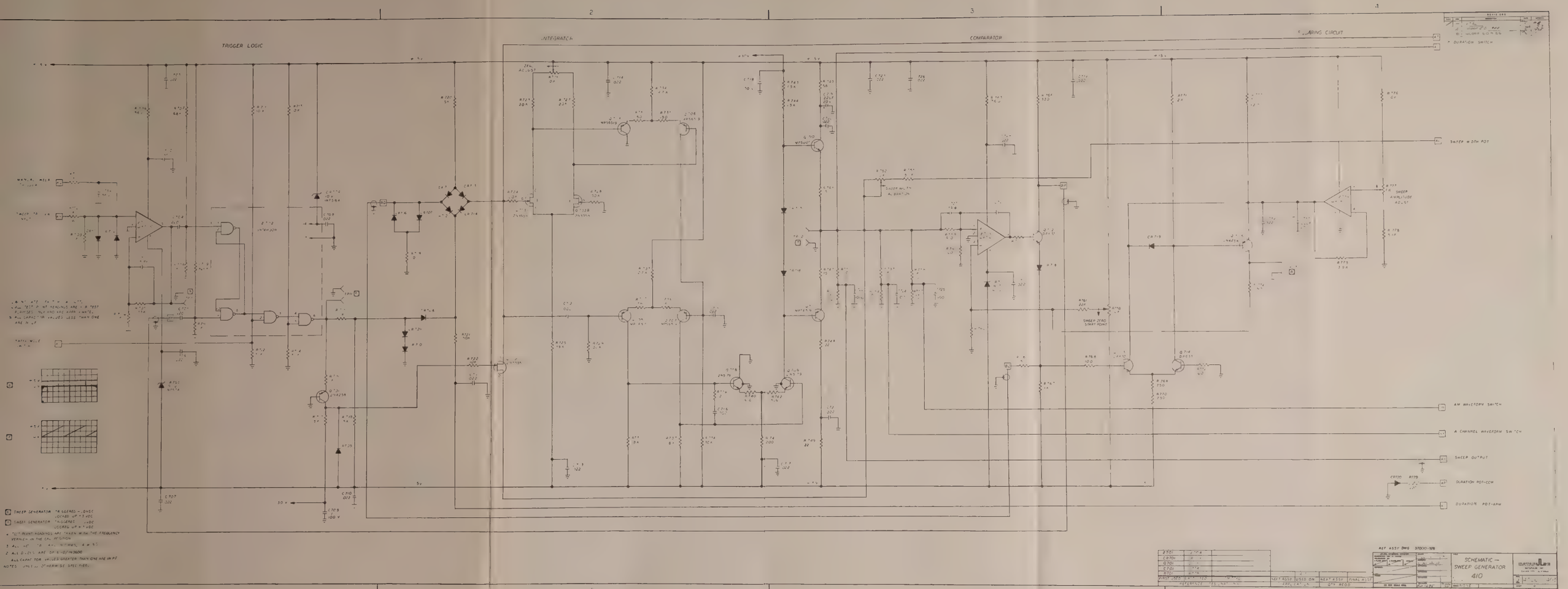
REF. ASSY. DWG -37000-928

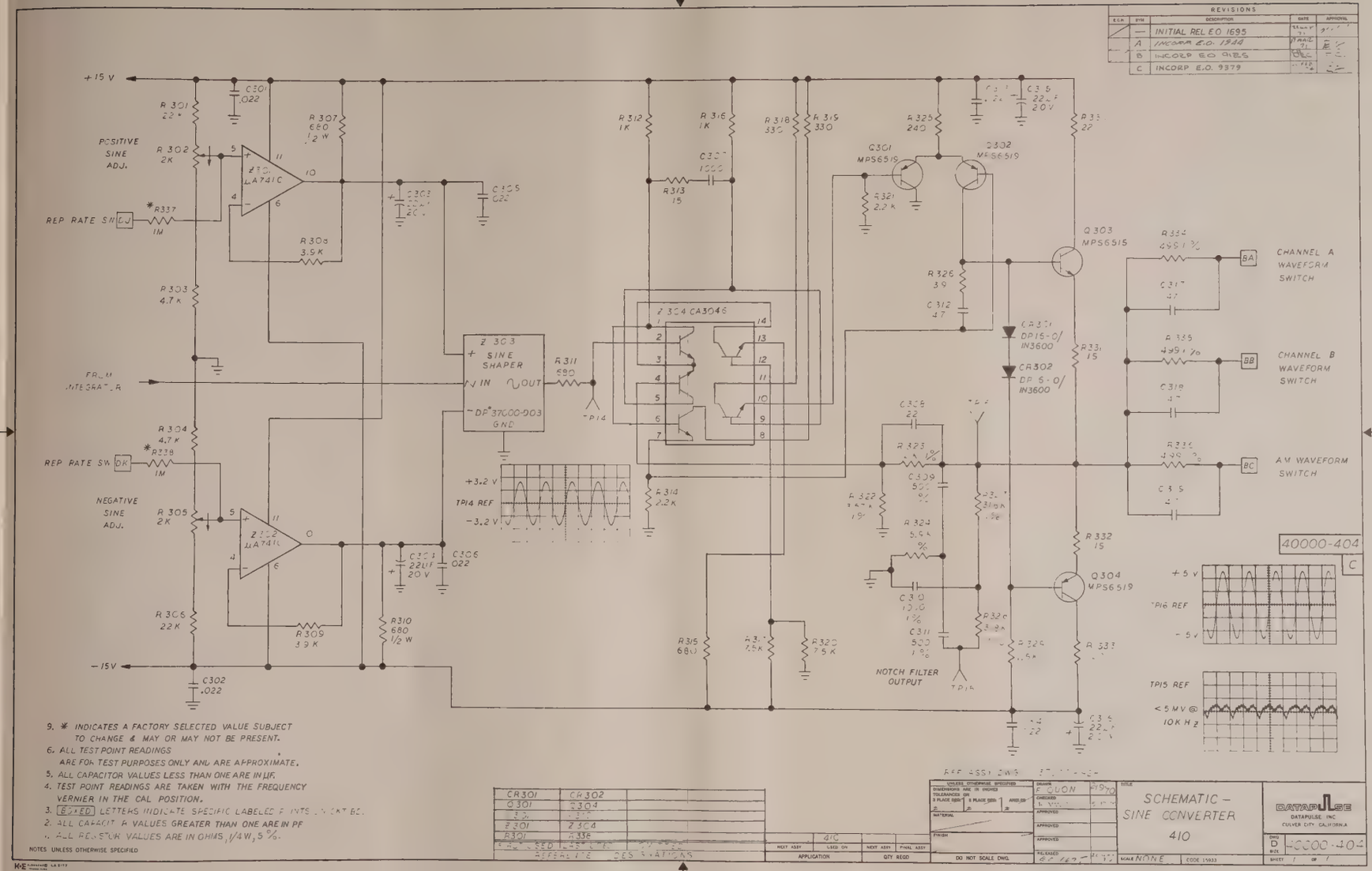
F. D.	8/11	
DOD	8/26	
CKD/TS	CB/CS	CRD/JJ
A. D.	8/5	
A. D.	8/18	12-2-96

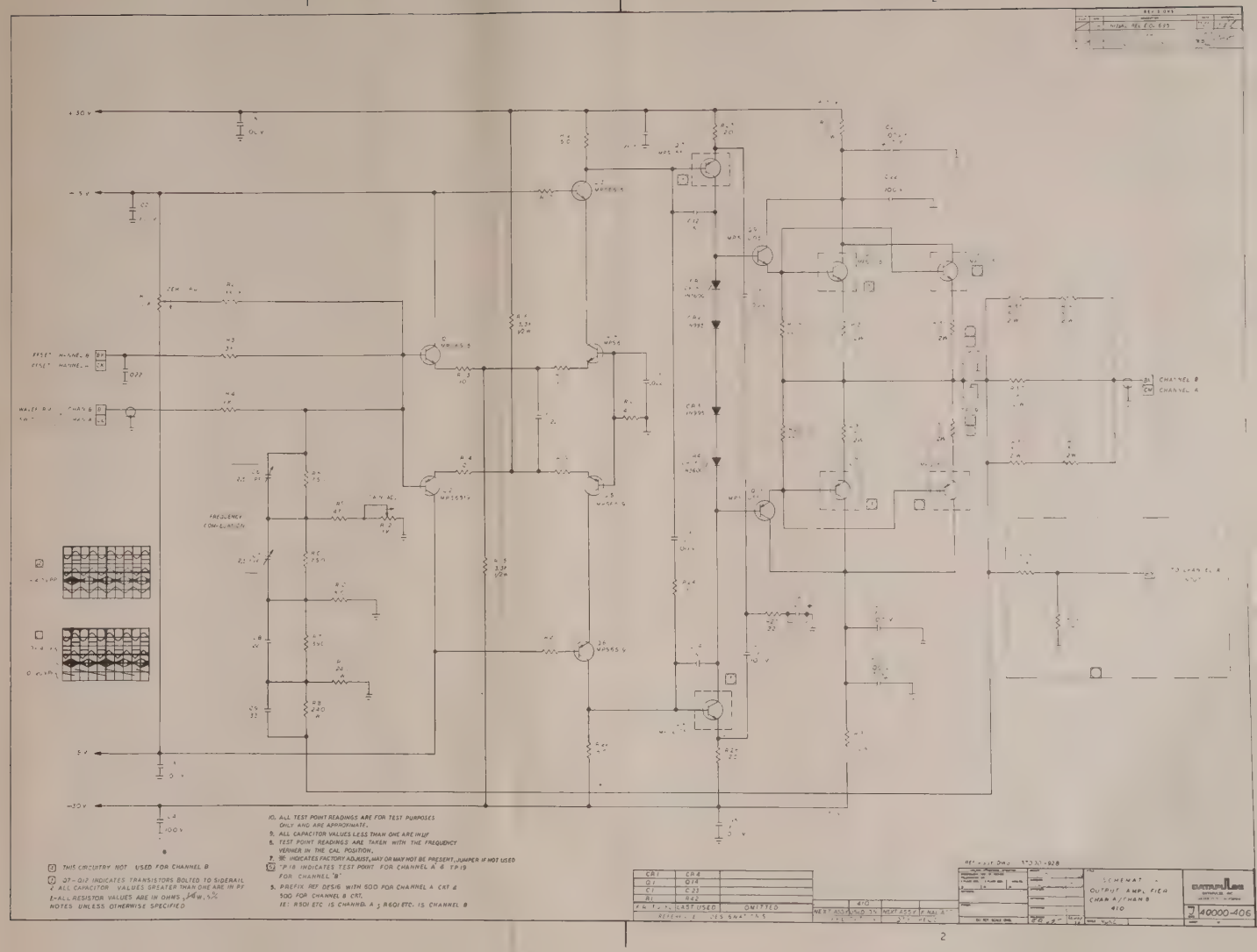
SCHEMATIC - MAIN GENERATOR 410

DATAPULSE INCORPORATED

40000-402


TRIGGER LOGIC
INTEGRATOR
COMPARATOR
SHAPING CIRCUIT
DURATION SWITCH
SWEEP WIDTH POT
SWEEP AMPLITUDE ADJ
SWEEP ZERO START POINT
AM WAVEFORM SWITCH
A CHANNEL WAVEFORM SWITCH
SWEEP OUTPUT
DURATION POT-CCW
DURATION POT-CW
SCHEMATIC — SWEEP GENERATOR 410


REVISIONS
INITIAL REL EO 1695
INCORP E.O. 1944
INCORP EO 9125
INCORP E.O. 9379
+15 V
-15V
POSITIVE SINE ADJ.
NEGATIVE SINE ADJ.
REP RATE SW DJ
REP RATE SW DK
FROM INTEGRATOR
Z301 μA741C
Z302 μA741C
Z303 SINE SHAPER
DP*37000-903 GND
Z304 CA3046
Q301 MPS6519
Q302 MPS6519
Q303 MPS6515
Q304 MPS6519
CR301 DP15-0/IN3600
CR302 DP 5-0/IN3600
CHANNEL A WAVEFORM SWITCH
CHANNEL B WAVEFORM SWITCH
AM WAVEFORM SWITCH
NOTCH FILTER OUTPUT
TP14 REF
TP16 REF
TP15 REF
<5 MV @ 10K Hz
40000-404
9. * INDICATES A FACTORY SELECTED VALUE SUBJECT TO CHANGE & MAY OR MAY NOT BE PRESENT.
6. ALL TEST POINT READINGS ARE FOR TEST PURPOSES ONLY AND ARE APPROXIMATE.
5. ALL CAPACITOR VALUES LESS THAN ONE ARE IN μF.
4. TEST POINT READINGS ARE TAKEN WITH THE FREQUENCY VERNIER IN THE CAL POSITION.
3. BOXED LETTERS INDICATE SPECIFIC LABELED POINTS ON CKT BD.
2. ALL CAPACITOR VALUES GREATER THAN ONE ARE IN PF
1. ALL RESISTOR VALUES ARE IN OHMS, 1/4W, 5%.
NOTES UNLESS OTHERWISE SPECIFIED
CR301 CR302
Q301 Q304
Z301 Z304
R301 R336
REFERENCE DESIGNATIONS
APPLICATION
QTY REQD
DO NOT SCALE DWG.
SCHEMATIC – SINE CONVERTER
410
DATAPULSE INC
CULVER CITY CALIFORNIA
40000-404
SCALE NONE
CODE 15933



1. THIS CIRCUITRY NOT USED FOR CHANNEL B
2. Q7 - Q12 INDICATES TRANSISTORS BOLTED TO SIDERAIL
3. ALL CAPACITOR VALUES GREATER THAN ONE ARE IN PF
4. ALL RESISTOR VALUES ARE IN OHMS, 1/4 W, 5%
NOTES UNLESS OTHERWISE SPECIFIED

10. ALL TEST POINT READINGS ARE FOR TEST PURPOSES ONLY AND ARE APPROXIMATE.
9. ALL CAPACITOR VALUES LESS THAN ONE ARE IN UF
8. TEST POINT READINGS ARE TAKEN WITH THE FREQUENCY VERNIER IN THE CAL POSITION.
7. ✱ INDICATES FACTORY ADJUST, MAY OR MAY NOT BE PRESENT, JUMPER IF NOT USED
6. TP 18 INDICATES TEST POINT FOR CHANNEL A & TP 19 FOR CHANNEL "B"
5. PREFIX REF DESIG WITH 500 FOR CHANNEL A CKT & 500 FOR CHANNEL B CKT.
IE: R501 ETC IS CHANNEL A ; R601 ETC. IS CHANNEL B

CR1	CR4	
Q1	Q14	
C1	C23	
R1	R42	
FIRST USED	LAST USED	OMITTED
REFERENCE DESIGNATIONS		

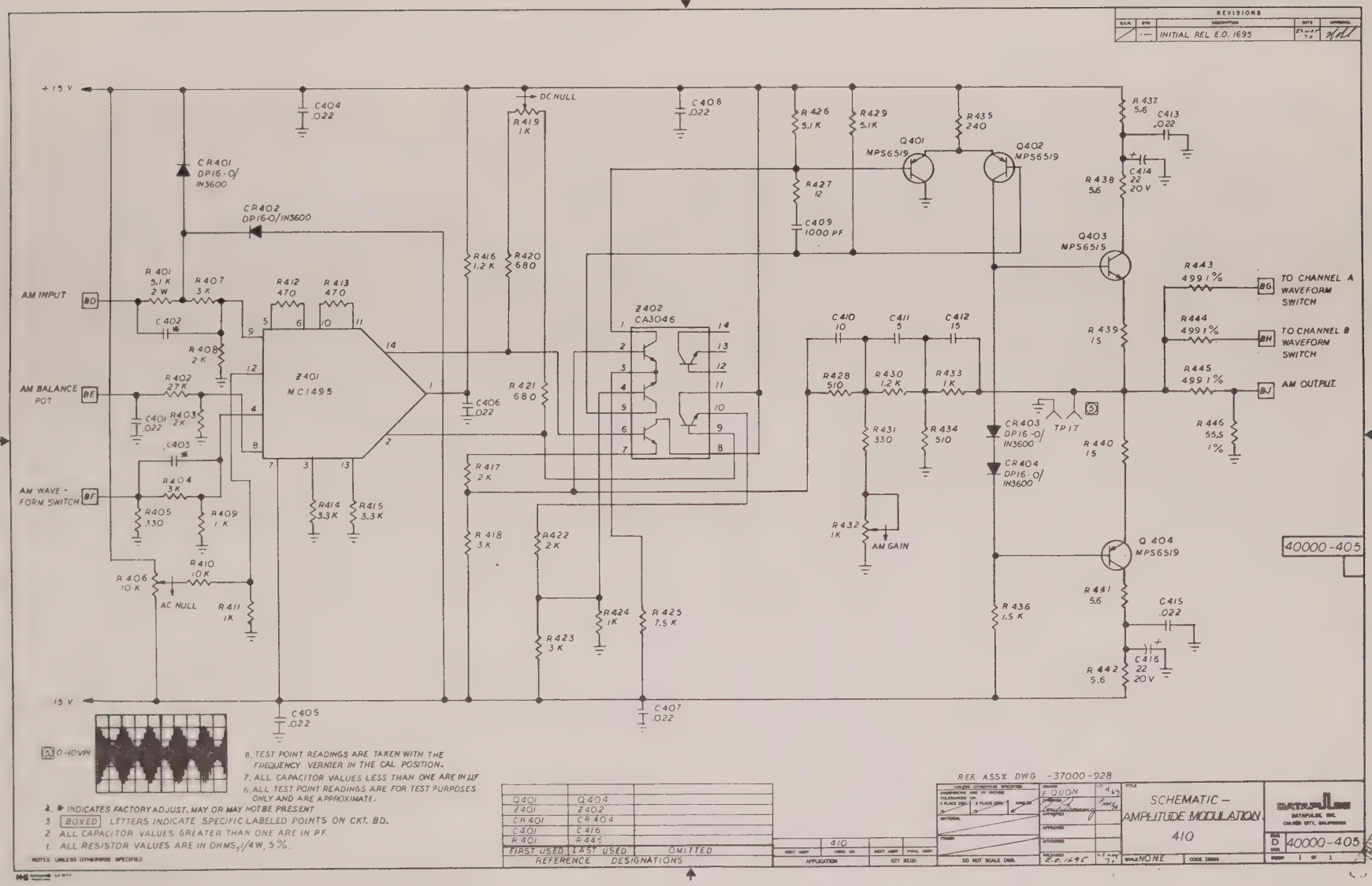
410			
NEXT ASSY	USED ON	NEXT ASSY	FINAL ASSY

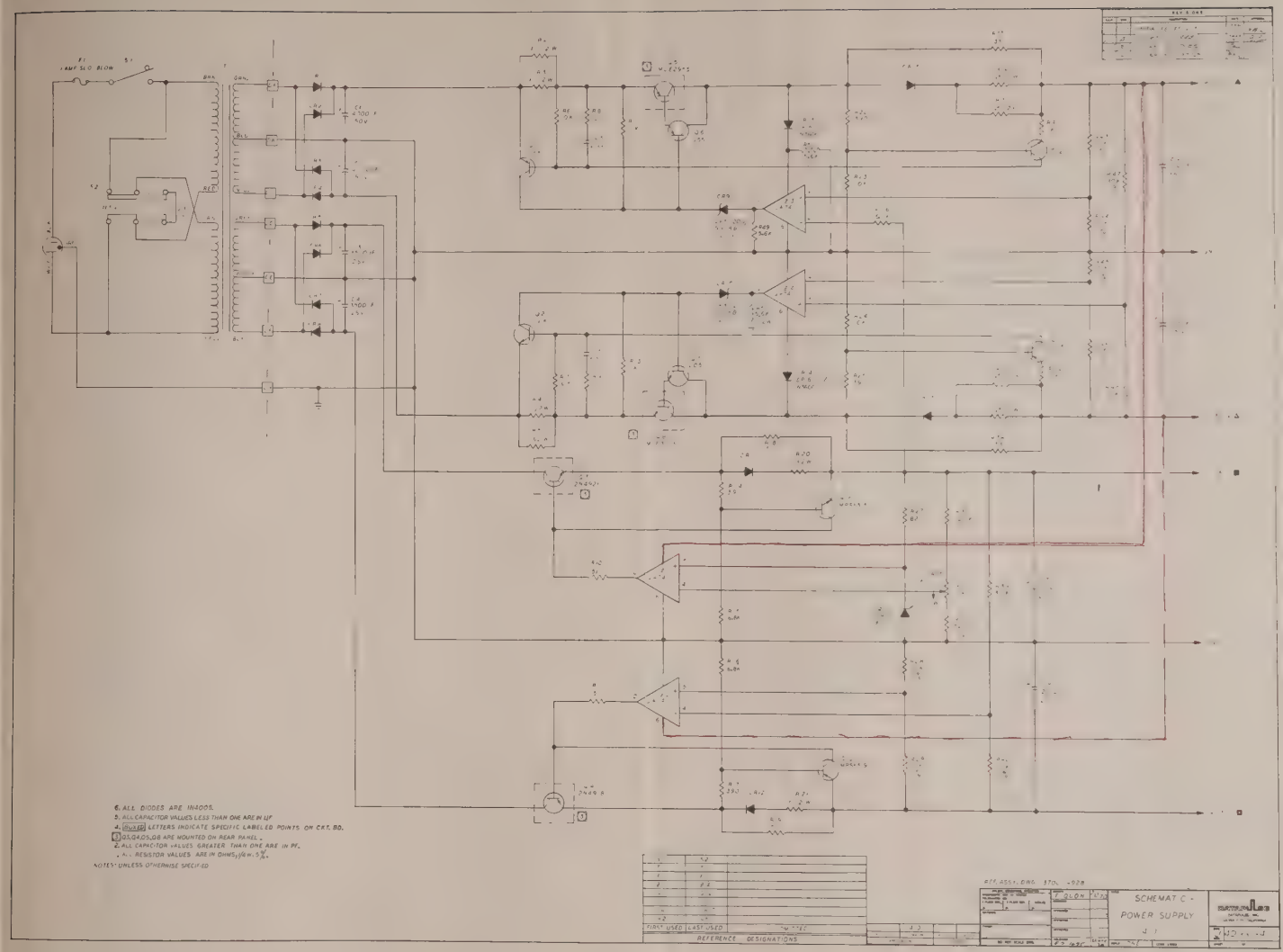
REF PART DWG 37000-928

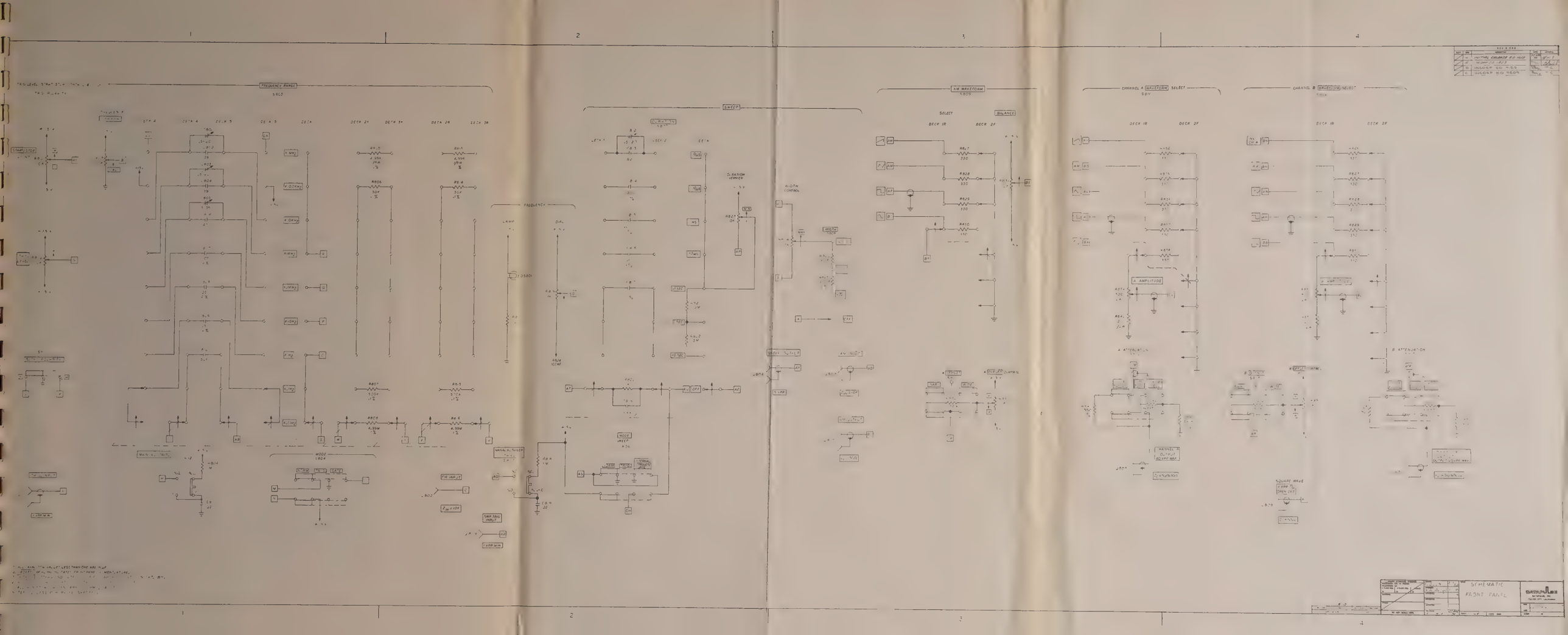
SCHEMAT - OUTPUT AMPLIFIER CHAN A/CHAN B 410

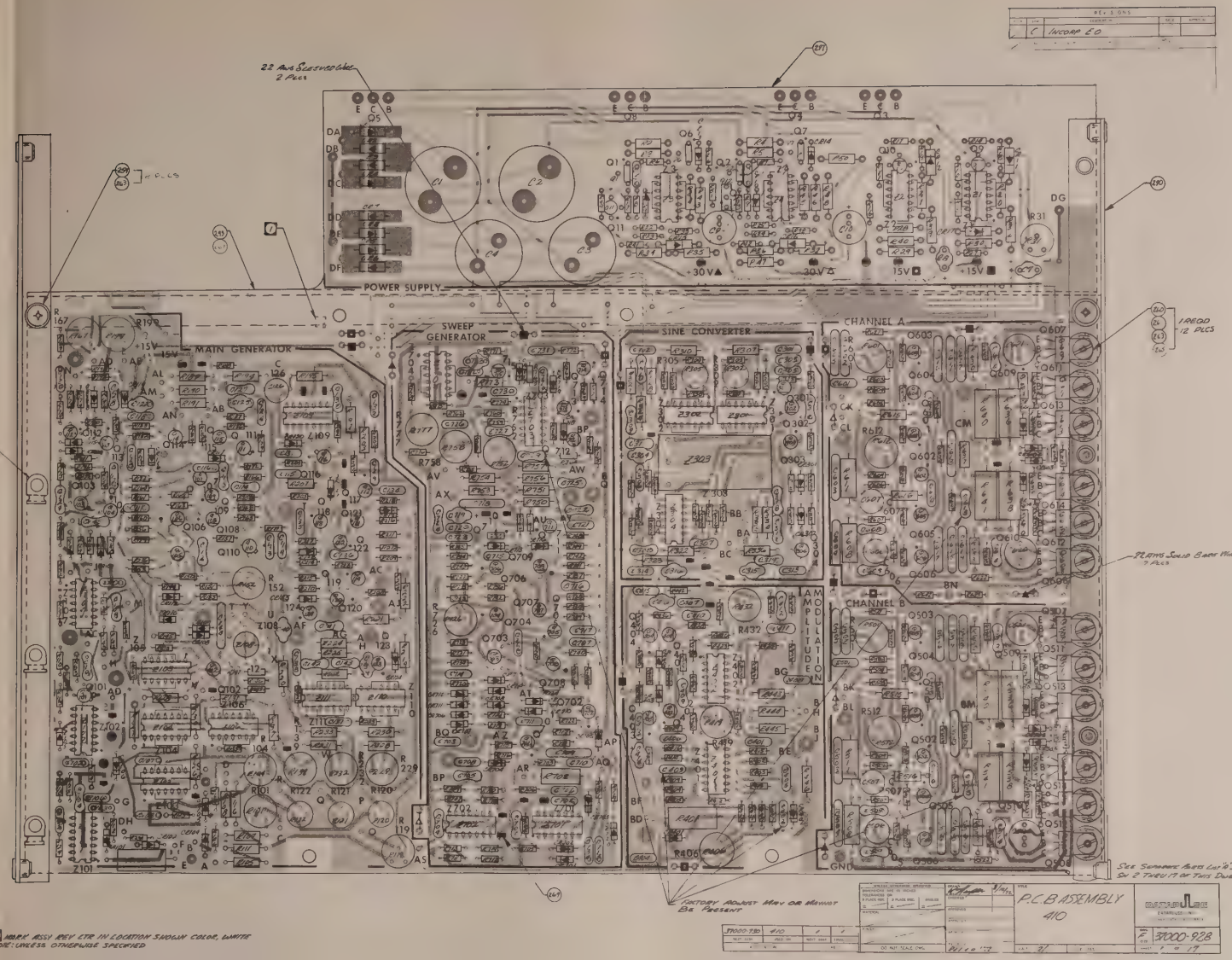
DATAPULSE

40000-406


REVISIONS
INITIAL REL E.O. 1695
+15 V
-15 V
C404 .022
C408 .022
DC NULL
R419 1K
CR401 DP16-0/ IN3600
CR402 DP16-0/IN3600
R401 5.1K 2W
R407 3K
R412 470
R413 470
AM INPUT
BD
C402 *
R408 2K
AM BALANCE POT
BE
R402 27K
C401 .022
R403 2K
C403 *
AM WAVE-FORM SWITCH
BF
R404 3K
R405 330
R409 1K
R410 10K
R406 10K
AC NULL
R411 1K
Z401 MC1495
R414 3.3K
R415 3.3K
R416 1.2K
R420 680
R421 680
C406 .022
R417 2K
R418 3K
R422 2K
R423 3K
R424 1K
R425 7.5K
C405 .022
C407 .022
Z402 CA3046
R426 5.1K
R429 5.1K
R435 240
Q401 MPS6519
Q402 MPS6519
R427 12
C409 1000 PF
R437 5.6
C413 .022
C414 22 20V
R438 5.6
Q403 MPS6515
C410 10
C411 5
C412 15
R428 510
R430 1.2K
R433 1K
R431 330
R434 510
CR403 DP16-0/ IN3600
CR404 DP16-0/ IN3600
TP17
R432 1K
AM GAIN
R439 15
R440 15
R443 4991% TO CHANNEL A WAVEFORM SWITCH
BG
R444 4991% TO CHANNEL B WAVEFORM SWITCH
BH
R445 4991% AM OUTPUT
BJ
R446 55.5 1%
Q404 MPS6519
R441 5.6
C415 .022
C416 22 20V
R442 5.6
R436 1.5K
40000-405
0-10VPP
8. TEST POINT READINGS ARE TAKEN WITH THE FREQUENCY VERNIER IN THE CAL POSITION.
7. ALL CAPACITOR VALUES LESS THAN ONE ARE IN µF
6. ALL TEST POINT READINGS ARE FOR TEST PURPOSES ONLY AND ARE APPROXIMATE.
4. * INDICATES FACTORY ADJUST. MAY OR MAY NOT BE PRESENT
3. BOXED LETTERS INDICATE SPECIFIC LABELED POINTS ON CKT. BD.
2. ALL CAPACITOR VALUES GREATER THAN ONE ARE IN PF.
1. ALL RESISTOR VALUES ARE IN OHMS, 1/4W, 5%.
NOTES UNLESS OTHERWISE SPECIFIED
Q401 Q404
Z401 Z402
CR401 CR404
C401 C416
R401 R445
FIRST USED LAST USED OMITTED
REFERENCE DESIGNATIONS
410
APPLICATION
REF ASSY DWG -37000-928
DO NOT SCALE DWG.
SCHEMATIC — AMPLITUDE MODULATION 410
DATAPULSE INC.
CHULA VISTA, CALIFORNIA
40000-405
SCALE NONE
CODE 18883
SHEET 1 OF 1


SCHEMAT C -
POWER SUPPLY
NOTES: UNLESS OTHERWISE SPECIFIED
4. LETTERS INDICATE SPECIFIC LABELLED POINTS ON CKT. BD.
REFERENCE DESIGNATIONS

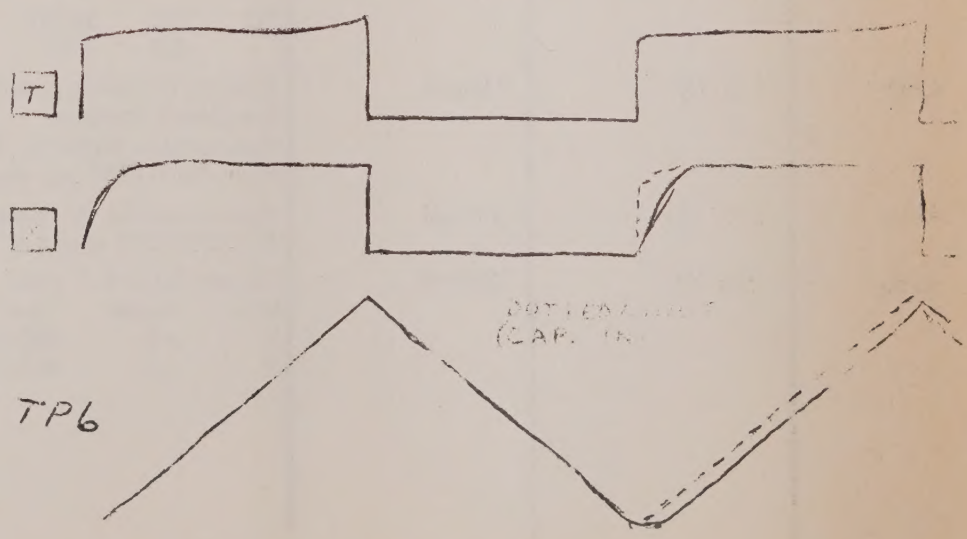

FREQUENCY RANGE
SWEEP
AM WAVEFORM
CHANNEL A WAVEFORM SELECT
CHANNEL B WAVEFORM SELECT
SELECT
BALANCE
DECK 1R
DECK 2F
A AMPLITUDE
A ATTENUATION
B ATTENUATION
FREQUENCY
DIAL
WIDTH CONTROL
DURATION VERNIER
MODE SWEEP
MANUAL SWEEP
FM INPUT
SQUARE WAVE
SCHEMATIC
FRONT PANEL



VIKING LABORATORIES INC.

E. O. NO.	EFFECTIVE DATE	DWG. NO.	CHANGE
3933	5 - 12 - 72	40000-407	Change R817 from 10 ohm, ¼ W to 56 ohm, ¼ W, P/N10010-560.
3938	5-18-72	37000-928	Change C613 on the left of R641 to C618 (duplicate, one next to R637 ok). Change C513 on the left of R541 to C518 (duplicate, one next to R537 ok).
3951	6-3-72	40000-401	For 230 volt operation, change the current value of the fuse to the next size over ¾ the current value at 115 volt operation.
4071A	8-23-72	40000-402 37000-928	Delete R236 and replace with two diodes, DP16-0 P/N22164-000 at the cathode of CR113 to ground.
4079	9-1-72	37000-928	Change C505 (next to Q506) to C506.
4081	9-7-72	40000-401	Install whole beads on emitter of Q3, Q4, Q5 and Q8.
4102	9-19-72	37000-928	Turn Z2 180° from the direction now showing and add 1 nylon screw P/N16690-003, 1 washer, P/N16750-003 and 1 kep nut, P/N16710-006 for Q512.
3938A	10-25-72	37000-928	Delete C518 and C618, 220 pF, P/N11077-221 and install jumper.
4207	11-13-72	40000-401	Void E.O. 3951 – For 230 volt operation, change the rating of the fuse to ¾ the value of the 115 V rating. Replace with nearest higher standard value (i.e.), 115 V = 1 amp, 230 V = ¾ amp.
4197	11-28-72	Manual	Make the following changes to Table 4-1 on page 4-12: FROM: DIAL RANGE COUNTER INDICATION 0.2 X0.01 484 s to 516 s 0.2 X0.1 41.6 s to 5.84 s TO 0.2 X0.01 416 s to 625 s 0.2 X0.1 41.6 s to 62.5 s
4256	1-5-73	Manual	Add the following paragraph to Section I, following Frequency Stability: Temperature Stability: The frequency will not drift more than 0.05% per degree centigrade.
4270	1-17-73	Manual	Add to Section IV, paragraph 4.4.8, step (a) the word FREQUENCY ahead of VERNIER.
4286	2-8-73	Manual	Change Table 4-1 from: Dial Range Counter Indication 2 X1 490 ms to 520 ms TO: 2 X1 490 ms to 510 ms

E. O. NO.	EFFECTIVE DATE	DWG. NO.	CHANGE
4321	3-22-73	Manual	Section IV, paragraph 4.3.2 Power Supply Calibration step (i), change last sentence from: and verify a reading of -30 ±0.3 volts to: and verify a reading of -30 ±0.5 volts.
4330	3-27-73	40000-404 37000-928 40000-402	Add an asterisk (*) after R337 and R338. Add a ground lug from screw to the ground plane at the sine converter Change C145 from 10 pF, P/N11077-100 to 22 pF, P/N11077-220.
3585A	5-8-73	Manual	Section IV, paragraph 4.4.8: Add to the note followirg step (c) "until minimum frequency is obtained".
4446	7-10-73	37000-928	Change R31, R101, R232, R139, R199, R229, R419, R432, R512, R612 and R777 from 1 k, ¼ W, 20%, P/N10437-102 to 1 k, ½ W, 20%, P/N10435-102. Change R119, R152, R167, R406, R501, R601, R726, R752, R758 and R104 from 10 k, ¼ W, 20%, P/N10437-103 to 10 k, ½ W, 20%, P/N10435-103.
4590	11-14-73	40000-402 37000-928	Change CR110 and CR112 from DP16-0, P/N22164-000 to MPS6519, P/N12605-018 (collector/base connected together and used as a cathode).
4616	12-10-73	Manual	Section IV, Table 4-1, page 4-12: Change 99.90 kHz to 101.0 kHz TO 99.00 kHz to 101.0 kHz.
4670	2-28-74	40000-402 37000-928	Add 15 pF capacitor, P/N22077-150 between point X and T per following drawing.



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